

Phambe

HERE'S HOW YOU

CAN

DO IT IN

SCIENCE

BIOLOGY

CHEMISTRY

GEOLOGY

PHYSICS

HERE'S HOW YOU CAN DO IT IN SCIENCE

COMPILED BY ANNE SKINNER

CONTENTS

BIOLOGY	Section 1
CHEMISTRY	Section 2
GEOLOGY	Section 3
PHYSICS	Section 4

**HERE'S HOW YOU
CAN DO IT
IN
BIOLOGY**

Section 1.

HERES HOW YOU CAN DO IT IN BIOLOGY

CONTENTS

Studying Micro-organisms: Yeast	1
Experiments for 2 Unit Biology Elective	4
Growing Plankton	10
Weighing a Cucumber as it Grows	11
A Simple Experiment to Demonstrate Catalyse Activity	13
The Use of Illustrated Keys for Classification in Schools	16
Natural Selection - A Board Game	19
Activities with the Microscope	24
Genetics Wheel	35
The Kidney - A Scripted Role Play	36
Crafty Science. The Art and Craft and Science Show?	38
The Arbitrary Nature of Classification	41

STUDYING MICRO-ORGANISMS: YEAST (SEN 1979, Vol. 28 No. 4)

Lyn Thickett, Wiley Park G.H.S.

In both the Senior and Junior schools, the concept of a micro-organism is taught and is usually accompanied by experiments involving the growing of micro-organisms from various sources on agar plates. Because of the possibility of summoning up a pathogen during this process, it is safer to use a 'tame' micro-organism, in this case yeast. (The experiment is even more memorable if the 'experimentee' gets eaten at the end of the day by the experimenter).

Junior Experiment

Aim

To observe the activity of a micro-organism when given ideal conditions in which to live.

Method

1. In a 400mL beaker cream together 30g of yeast (live) with 50g of sugar.
2. Add 200mL of warm water and stir well.
3. In a second 400mL beaker place 50g of sugar and enough warm water so that the level in this beaker is equal to the level in the first beaker.
4. Stand both beakers in a warm place and observe what is happening.

Results

1. Describe the initial appearance of the contents of the two beakers.
2. After several minutes, what can you see happening? What can you hear? What can you smell?
3. At the end of twenty minutes, is there a difference in the mixture levels?

Conclusions

Your conclusion to this experiment should contain answers to the following questions.

1. What is the function of the sugar?
2. Why did the water need to be warm?
3. Suggest two ways in which yeast could be prevented from growing.

This is a strict science experiment, but if the students want to eat the yeast in the form of bread, the whole experiment can be carried out using clean jam jars and cooking equipment. The above experiment will occupy a 40 minute period, but if bread (or any yeast recipe) is to be made, the teacher must be willing to spend several hours after this lesson while the recipe proves. Alternatively, the students may like to take their yeast culture home and make bread for the family.

Simple Bread Recipe

Place 4 cups of plain flour, 1/2 cup of powdered milk and salt in a large basin. Make a well in the middle of the flour, add the yeast mixture and another 1/2 cup of warm water. Mix to a soft dough and then knead on a floured sheet for 5 minutes. Place on greased trays and allow to rise until double in size. Cook in a hot oven until golden brown.

Senior Experiments

The senior experiments involve:

- (a) the rate of production of gas by the yeast as it grows
- (b) the determination of the gas given off
- (c) microscopic examination of the yeast.

Method

The same as in the junior experiment up to step 3.

(a) Rate of production of gas

1. Transfer 100mL of the yeast mixture to a small flask, fitted with a stopper and delivery tube.
2. Collect the gas produced by the downward displacement of water in a 10mL measuring cylinder.
3. Record the amount of water displaced every 10 minutes for at least 60 minutes, then after 2 hours, 3 hours, etc.
4. Plot a graph of rate of production of gas.

(b) Determination of gas given off

1. From the remaining solution, transfer 50mL to another flask fitted with a delivery tube.
2. Pass the gas produced over limewater.
3. Record observations and state conclusion.

(c) Microscopic observation

1. Dilute 1mL of the remaining yeast solution with 9 mL of water.
2. Make a wet mount of some of the dilute solution.
3. Sketch the appearance of the yeast organism.

Questions

Sometimes bakers produce breads called 'sour-dough' breads. Describe how this bread is made.

Facts About Yeast

Fresh live yeast should have a creamy beige colour and a firm consistency which crumbles easily when broken up. It can be stored in plastic in a cool place for up to 5 days, in a refrigerator for up to one month or in a freezer for up to one year.

Do not cream yeast too much as this results in the breakdown of living yeast cells. Dried yeast can be used but results are often slow as the yeast has to be reactivated first.

EXPERIMENTS FOR 2 UNIT BIOLOGY ELECTIVES

(SEN 1980, Vol. 29 No. 4)

Pat Funnell.

The following experiments require no special equipment, would take students only a short period of time to set up in class and would not require hours of preparation on the part of the laboratory assistant. Results are rapid, so the entire procedure and discussion can be completed within the normal double practical period.

A. Rates of Oxygen Production During Photosynthesis

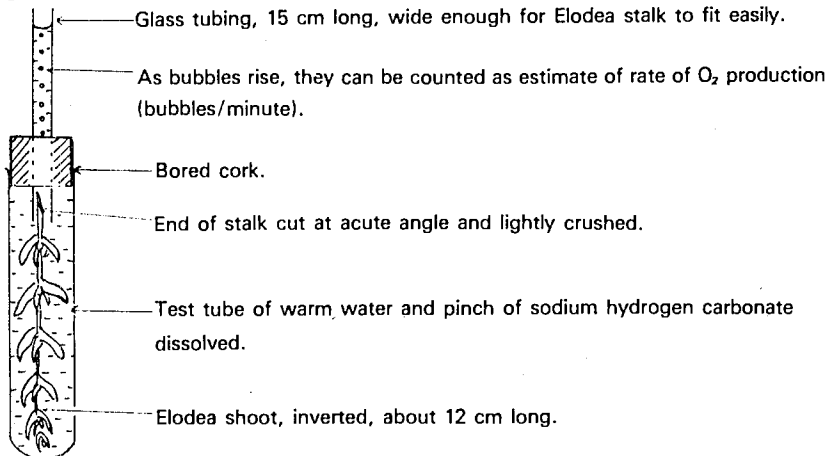
Introduction

In these experiments, easily assembled apparatus is used to test the influence of various environmental factors on the rate of gas production in *Elodea*. Such factors as light intensity, temperature and presence of hydrogen carbonate ions can be studied.

Materials per group

- 10 large test tubes
- 10 corks, bored, each with a length of glass tubing, 7-8mm in diameter, 15-16cm long
- 10 *Elodea* shoots
- 6 beakers, 6 thermometers (groups can share these)
- 1 scalpel or razor blade
- stop watch or clock for timing
- light meter (optional)
- sodium hydrogen carbonate.

Procedure



Procedure

Each group should select the required number of *Elodea* stalks all of the same lengths and condition. Remove leaves from the lower 2 or 3 nodes. Cut the stem at an acute angle and crush the end lightly with the flattened scalpel blade. Insert the cut end of the stem into the glass tubing so that it fits loosely, then lower into a test tube of lukewarm water. (Results are best if water is hand-warm or around 30°C.) Raise the water level in the glass tubing as the cork is inserted in the test tube so that bubbles have approximately 5-10cm to rise above the cork: this makes counting easier. It may be necessary to suck on the open end of the glass tubing while inserting the cork in order to adjust the level of the water, so that the end should be flamed smooth.

Set up all the test tubes, then allow 5-10 minutes before starting to count the bubbles as they rise from the cut end of the stem. As a control, set up one test tube of *Elodea* from which all the leaves have been carefully removed.

Notes

1. If it is necessary to move the apparatus, try not to shake or disturb, as it appears that a high concentration of oxygen in the water is necessary before bubbling will occur from the stem.
2. A pinch of sodium hydrogen carbonate added to the water in each test tube when setting up will increase the speed of the reaction.
3. If *Elodea* is not available, try using another water weed with aerenchyma, such as *Valisneria*.
4. Each group should standardise their cutting and crushing technique in an attempt to get bubbles of approximately equal size.
5. If no bubbles emerge from the stem, as happens rarely, repeat cutting and crushing procedure.
6. In some cases, bubbling is so rapid students will need to be competent at keeping a tally.

Experiment 1. Influence of Light Intensity on Rate of Gas Production in *Elodea*

Follow the procedure above to set up 3 test tubes (plus control). Place each in a beaker of lukewarm water at identical temperatures. Place a thermometer in each beaker to record 'environmental temperature' at beginning and end of the experiment. Place the control in the beaker with the best illuminated test tube.

Method A

Place beakers at different distances from microscope lamps; 5cm, 10cm, 20cm. (Several groups can share a beaker and a lamp). Assume an inverse relationship between light intensity and distance from the lamp. Count bubbles emitted for 10 minutes.

Method B

Choose sites with 3 different light intensities, such as bright (e.g. window sill not in direct sunlight), medium and dimly lighted. A light meter can be used to measure light intensities, or qualitative estimates can be made. Count bubbles for 10 minutes.

Method C

Use one set of apparatus only and count bubbles emitted when it is placed in each of the 3 sites suggested in Methods A or B. Record bubbles per minute. Record environmental temperature for each test tube before and after each count.

Experiment 2. Influence of Temperature on Rate of Gas Production in *Elodea*

Follow the procedure above to set up 4 test tubes (plus control). Place each in a beaker of water at a different temperature. Wait 10 minutes approximately, for temperature within the test tube to approach that in the beaker, then count the bubbles for 10 minutes. Record environmental temperature at the beginning and end of each count. (Groups can share a beaker.)

Suggested temperatures:

- ice water
- room temperature
- warm water (about 30-40°C)
- hot water (about 60-80°C).

Precise temperatures are not important. To maintain high temperatures a water bath will be necessary. Have the control with the test tube in warm water or at room temperature.

Record bubbles per minute. Record temperature before and after counting. Students can graph results.

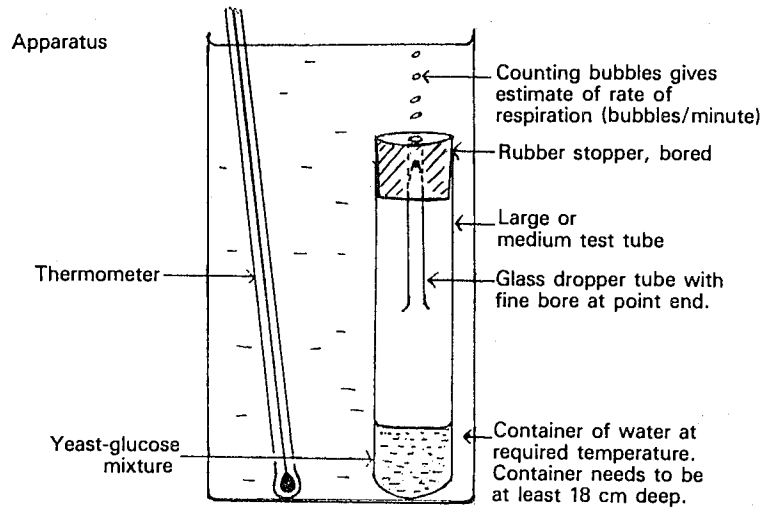
Experiment 3. The Influence of Hydrogen Carbonate Ions on the Rate of Gas Production in *Elodea*.

Follow the procedure to set up 3 (or more) test tubes. Vary the concentration of sodium hydrogen carbonate solution in each test tube. Suggested concentrations:

- tap water only
- 0.5% solution
- 5% solution.

The class might wish to try higher concentrations or to test the influence of other ions. Ensure each test tube is at the same temperature and under the same light intensity.

B. Rates of Respiration in Yeast



(Adapted from *Laboratory Biology. Investigating Living Systems*. Albert Kaskel, Paul J. Hummer Jr., James E. Kennedy, Raymond F. Oram. Charles E. Merrill Publishing Co. Columbus, Ohio, 1979.)

Notes

The stopper and dropper tube must fit firmly. The opening of the glass tube must be well above the yeast glucose mixture. The outer container must be at least 18cm deep. Some suggestions include:

- * 1L or 2L milk cartons or juice cartons
- * plastic soft drink bottles with the top cut off
- * large coffee jars or storage jars on issue to schools

Materials per Group

- 5 or more sets of test tubes
- 5 or more sets of rubber stoppers
- 5 or more sets of dropper tubes
- 1 thermometer 50 or 110°C
- 1 large container for water bath
(where the influence of temperature is to be studied, groups will require 1 thermometer and 1 container per temperature, but these can be shared by several groups)
- approximately 10g compressed yeast
- 1 balance
- 100mL of glucose solution, 10%, made up using cooled boiled tap water (except where influence of substrate is to be studied, concentration of glucose

solution need not be accurate. one teaspoon per 100mL is sufficient)

1 x 10mL pipette

ice, hot water, cold water

additional solutions for specific experiments.

Experiment 1. Influence of Temperature on Rate of Respiration of Yeast

Procedure

Place 2g of solid compressed yeast in each of 5 test tubes. Pipette 10mL of approximately 10% glucose solution into each test tube and shake well.

Prepare 5 water baths at different temperatures, e.g.

ice water at 0°C

cool, room temperature, i.e. 20°C

warm, 35°C

hot, 60°C

very hot, 80°C.

Ensure stoppers are firmly in place, then place one set of apparatus in each container of water. Wait 2 minutes for the temperature within the test tube to reach the environmental temperature. Tally bubbles for, say, 10 minutes. Record temperature at commencement and at conclusion of counting. A control test tube without yeast could be set up and placed in the water bath at 35°C.

Note

If it is necessary to use dried yeast, mix 5g dried yeast per 100mL glucose solution and allow it to activate for about 30 minutes before setting up the experiment.

Experiment 2. Influence of Substrate on Rate of Respiration of Yeast

Follow the procedure to set up 5 respirometers, each with 10mL of a different substrate. Label stopper tops with waterproof pen. Incubate at 35°C in a water bath.

Suggested substrates:

tap water only

glucose solutions, 5%, 10% and 20%

sucrose solutions

other sugar solutions as available

fruit juices, fresh or commercially available;

students may like to bring juices to try and the effect of preservatives could be tested.

Experiment 3. Influence of Presence of Other Substances

Follow the procedure to set up the required number of respirometers, each with yeast and 10mL of 10% glucose solution. Add the substance you wish to test, at different concentrations. Shake well. Label the stopper with waterproof ink. Incubate at 35°C in water bath.

Suggested substances to try:

5mL of sodium fluoride solution of 0.5M and 0.05M sodium chloride solution, as above

detergent, 1 drop, 10 drops, 2mL

disinfectant, as above

pH, add drops of dilute acid or alkali to give a range of pH.

Students may suggest testing other substances which might influence the 'well-being' of micro-organisms. In each case a control should be set up, containing yeast, glucose and a volume of water equal to the volume of solution used in one of the experimental test tubes.

GROWING PLANKTON (SEN 1980, Vol. 29. No. 4)

Harold Lea, Sydney Teachers College.

Plankton can be quickly grown by pouring sea water over some mud freshly collected from underneath mangroves. Add about 0.2g of Aquasol or other 'complete' fertiliser to every 100 mL of sea water and place in a covered beaker about 15cm from a 40 watt electric light bulb. The light is kept on continuously for 4 days, at which time an abundance of zoo-and phytoplankton, including diatoms, are visible on microscopic examination.

A similar technique using a) fresh tap water and garden soil and b) water from a non-saline permanent pond, was used. In both cases an abundance of phytoplankton developed after 7 days, but only scant zooplankton. Omitting Aquasol resulted in a smaller but significant amount of phytoplankton visible macroscopically on the surface of the beaker and in suspension.

Where the technique of adding Aquasol and light from a 40 watt bulb was used with water from a permanent fresh water pond containing abundant suspended organic matter, abundant phyto- and zooplankton resulted.

WEIGHING A CUCUMBER AS IT GROWS (SEN 1981 Vol. 30 No. 2)
P.W. Freeland, Science Review 59, March 1977

Figure 1. shows how an automatic top-pan balance was used to record continuous weight changes in a growing cucumber, attached to a pot-grown plant. Seeds of the greenhouse variety Topsy were sown in large pots during the first week of April; seedlings were grown in an unheated greenhouse until mid-June, then transferred to the laboratory as soon as young fruits had developed.

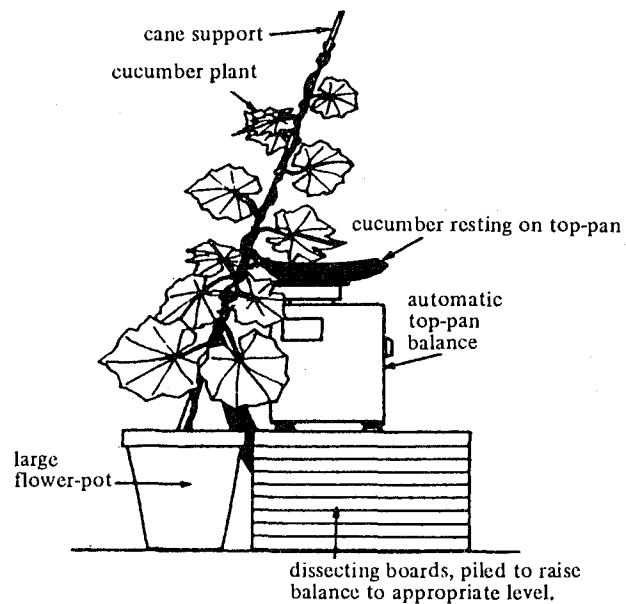


Figure 1. Arrangement of cucumber plant and top-pan balance

Each fruit, suspended from the plant by its pedicel, was placed on the top-pan and its weight recorded. The process was repeated daily over a period of 14-21 days, until the fruits were ready for cutting. In addition, weight changes in large cucumbers, exceeding 150g, were monitored on an hourly basis from 9.00 a.m. until 4.00 p.m. over a period of seven days. It was found that large fruits added anything from 0.7 to 1.9g per hour and that there was a periodic variation in these additions, with the largest gain occurring between 10.00am and noon. A typical set of results is shown in Figure 2. It should be noted, however, that weights shown on the graph are not the true weight of the fruit, as some of that weight is always borne by the pedicel.

This simple technique, apart from being applicable to other pot-grown plants such as tomatoes, peppers, runner beans, french beans and some cultivars of pea, can be used to investigate the effects of environmental factors, or chemical substances, on the growth rate of fruits. Alternatively it can be used to compare growth rates in different cultivars or species.

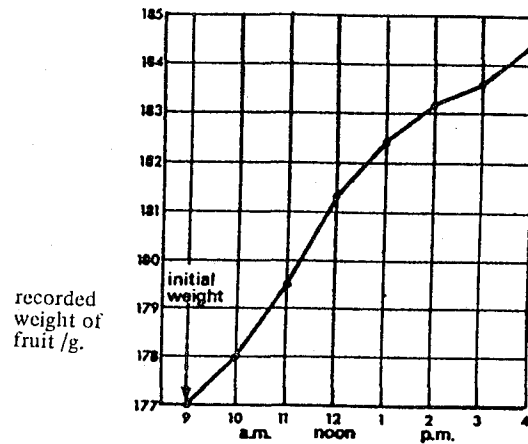


Figure 2. Changes in the weight of a large cucumber over a period of seven hours.

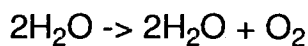
A SIMPLE EXPERIMENT TO DEMONSTRATE CATALASE ACTIVITY

(SEN 1981 Vol. 30 No. 2)

Damaris Cordery

Introduction

Catalase is a particularly active enzyme found in cells of almost all aerobic organisms, especially in animal tissues such as liver, kidney and blood. It consists of protein plus an iron-porphyrin group containing four atoms of iron per molecule. Its action is easily demonstrated qualitatively by adding hydrogen peroxide to liver extract; molecular oxygen is instantly liberated.



1mg of pure catalase liberates 2.740 litres of oxygen per hour at 0°C

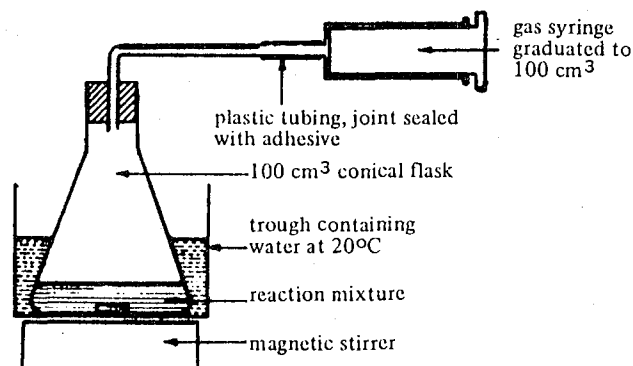


Figure 1.

Figure 1. shows the apparatus used to estimate the volume of gas evolved by the addition of liver extract to hydrogen peroxide.

Method

1. Preparation of the extract. Place about 25g of ox liver in a small coffee grinder for 5 minutes. Weigh out 1g of the homogenate, dilute with 100cm³ 0.9% sodium chloride solution and mix thoroughly.

2. Prepare 3% hydrogen peroxide by diluting 30% hydrogen peroxide.
3. Pipette 10cm^3 3% hydrogen peroxide into the conical flask, seal the apparatus and test for air leakages.
4. Adjust the temperature of the water bath to 20°C . This approximates to room temperature and eliminates constant adjustment of the water temperature during the experiment.
5. Switch on the magnetic stirrer to rotate at moderate speed. By clamping the flask in the same position relative to the platform during each trial, errors because of different speeds of stirring are eliminated.
6. Invert the flask containing the extract three times to ensure thorough mixing and take the sample from the centre of the flask with a 1cm^3 syringe.
7. Introduce the sample into the conical flask via the syringe and immediately seal the apparatus. At the same time, switch on the stop watch and record the volume of gas in the gas syringe at intervals of 30 seconds up to 5 minutes.
8. Repeat the procedure three times for each volume of extract, washing the flask containing the reaction mixture thoroughly between each trial.

Figure 2 gives a graphical summary of the results obtained.

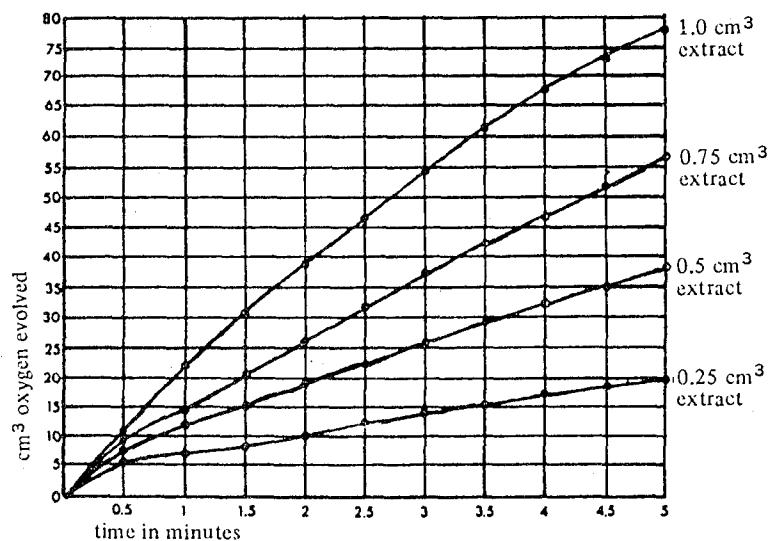


Figure 2. Graph of volume of oxygen evolved vs. time

Discussion

The activity of catalase makes it a suitable enzyme for study in schools. Qualitative demonstrations can lead to quantitative measurements of oxygen evolved. Sufficient oxygen is liberated for readings accurate to within 1cm^3 to be taken. Reproducible results are obtained with the same liver extract. It was hoped by making the experiment a comparative one to eliminate errors due to variations in liver, length of storage time, etc. Ideally, liver from freshly killed animals would be used but this is not obtainable in most schools. It was found that if the homogenate was frozen for a week before carrying out the experiment, consistent results were still obtained.

The use of a syringe to introduce the extract sample allows minimum escape of oxygen. This is important as catalysis begins immediately.

The experiment could be adapted to compare enzyme activity under different conditions, for example pH, temperature and in the presence of non-competitive and competitive inhibitors.

The apparatus can also be used to demonstrate catalase activity in other types of animal tissues such as blood. If 1cm^3 blood is diluted with 0.9 cm^3 0.9% sodium chloride solution and 0.5 cm^3 samples are used for each trial, good results can be obtained.

THE USE OF ILLUSTRATED KEYS FOR CLASSIFICATION IN SCHOOLS

(SEN 1983, Vol. 32 No. 2)

Leonie M. Kemp, Education Officer, Royal Botanic Gardens

Introduction

Two biological keys, using mainly diagrams and few words, were developed at the Royal Botanic Gardens, Sydney, for use with travelling kit materials. Results from trials of over 200 senior students showed the keys to be easier to use than similar worded keys in identifying a family of plants down to the genus level. Fewer mistakes were made using illustrated keys. The keys were also of particular use with ESL students, aiding language development with the use of words and diagrams. This type of key could also be used with junior high school students.

Use of Illustrated Keys

Teachers could develop their own illustrated keys to identify some of the plants growing in the school grounds. Only those features that can be clearly shown in diagrams should be used. Similar keys could be developed to identify some of the animals found near the school grounds. The key could also be used to identify non-living objects.

The keys can also be used to develop language with ESL students. The name of the illustrated feature could be added to the key.

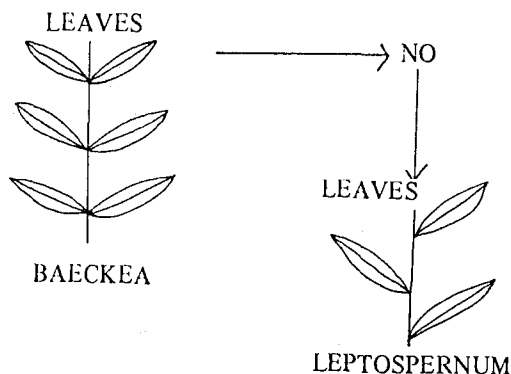
To develop the ability to compare and contrast, students can practise making simple keys using diagrams to distinguish between 3 or 4 different plant, animal or non-living specimens.

Advantages

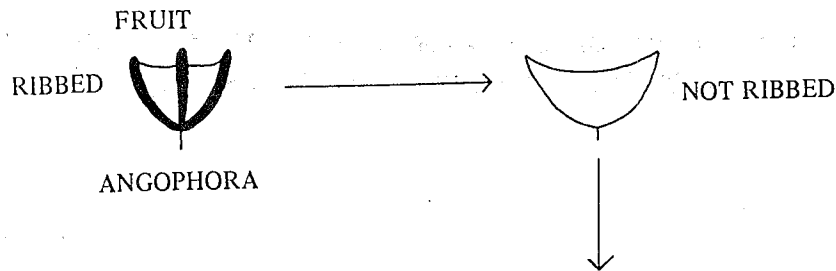
- * Comparison is made simpler than in conventional worded keys as the character studied is shown clearly.

Advantages

- * Comparison is made simpler than in conventional worded keys as the character studied is shown clearly.



- * The key is quicker to use as not as much reading is involved.
- * With the use of diagrams, ESL students are not hampered by unfamiliar words. The association of words and diagrams aids learning new languages.



- * Fewer errors are made following arrows, compared to conventional keys when following a sequence of numbered steps.
- * With fewer errors, more specimens can be identified in the same time available.
- * Because of the simplicity of this type of key, it could be used with junior high school students, eg. in distinguishing between major plant or animal groups or non-living objects.
- * Because the key is self-guided teachers have more time to correct major student errors or to point out additional features of the specimens.
- * Additional senses, such as smell, can be used with the aid of the teacher, eg. the scent of crushed leaves, the feel of bark, salty taste.

A Disadvantage

- * Some distinguishing characteristics between a group of specimens cannot be illustrated simply, thus reducing the number of specimens identified by the key.

Conclusion

Because illustrated keys are self-guided, teachers can spend more time with students developing language, correcting major errors and pointing out additional characteristics of the specimens. Their simplicity makes them ideal for use with junior and senior high school students as well as ESL students.

With the use of illustrations, biological terms can be eliminated. The key does not have to be restricted to biological specimens but could be used with non-living objects.

Because of the simplicity of this type of key, teachers could develop their own keys for use with specimens around the school.

Note: The author of this article has indicated that copyright for diagrams rests with the Education Unit of the Royal Botanic Gardens.

NATURAL SELECTION - A BOARD GAME (SEN 1983, Vol. 32 No. 2)

Anne Buffier, St Catherine's College, Singleton

Introduction

The following game was created in an effort to make the concept of natural selection easier for students in the lower streams of Years 9 and 10. Since natural selection is a continuous and usually long-term process, (with the exception of, say, some micro-organisms) any first hand observations are beyond the reach of school science classes. Examples are usually far removed from the students own experience, as in the case of the peppered moth, *Biston betularia* and the Galapagos finches.

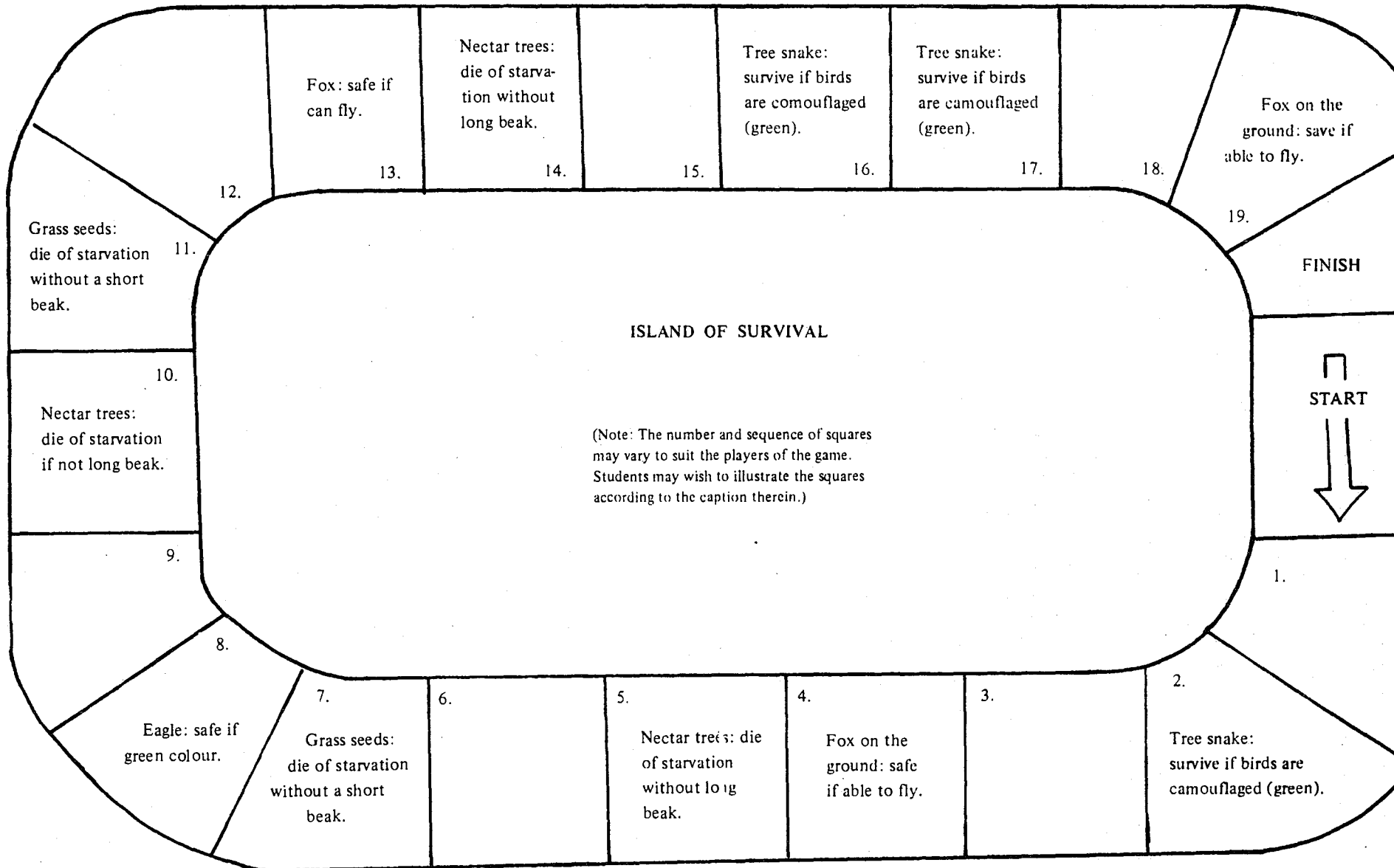
It was felt that if the students could "create" certain organisms AND the habitat in which they live, they might then have a better chance of viewing natural selection as the interaction between organism and environment that it is.

Materials

You will need:

- * a sheet of white cardboard
- * 30 cards (organism cards)
(10 of Type A, 10 of Type B, 10 of Type C)
- * die and container

Note: Although birds were used by Year 10 at our school, endless variations are possible. It is suggested that the choice of organisms (bird, fish, insect, worm, etc.) and its habitat be left to the students.



Method

Step 1: Students choose their organisms and decide on the kind of habitat it will live in. A circuit is drawn up on the cardboard with most squares illustrating some feature of their habitat.

Step 2: Students draw up their three types of organism cards. (10 of each.)

TYPE A	Camouflaged	Adapted for Escape from predators	Adapted for Obtaining main food source of habitat
TYPE B	Camouflaged	NO adaptation	Adapted for obtaining main food source of habitat
TYPE C	NOT camouflaged	Adapted for escape from predators	Not adapted for obtaining food

Step 3: Cards are placed face down in the centre of the board.

Step 4: A player selects a card from the top of the pile, throws the die and moves the appropriate number of squares.

Step 5: Birds completing the circuit go back to the bottom of the centre pile.

Step 6: Players score points each time one of their cards COMPLETES the circuit.

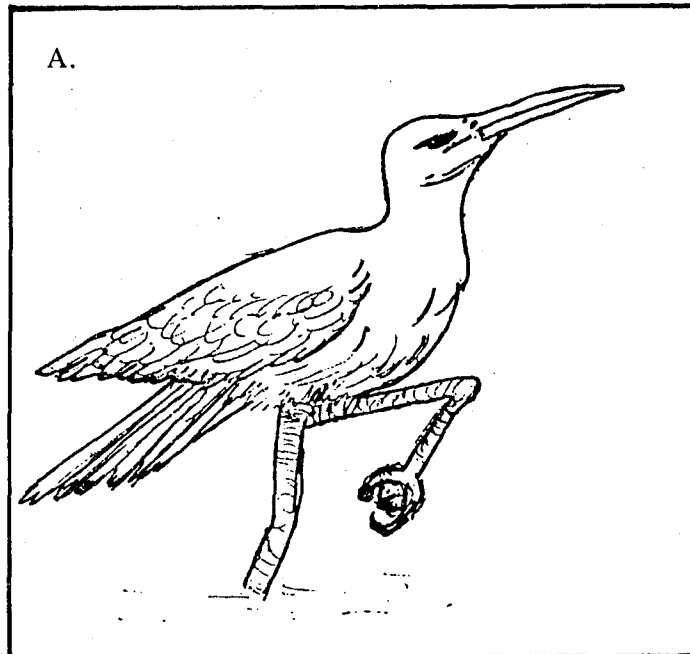
Step 7: Birds which are 'killed' along the way are put out of play. A player must then choose another card.

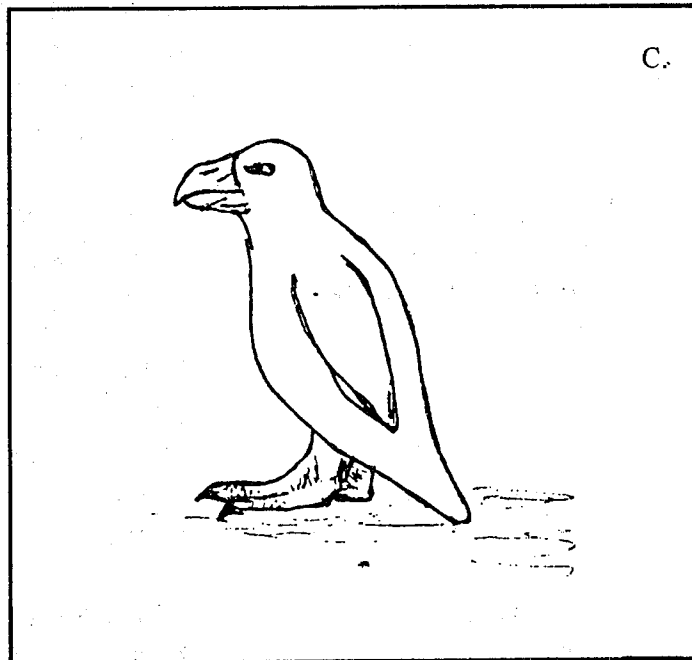
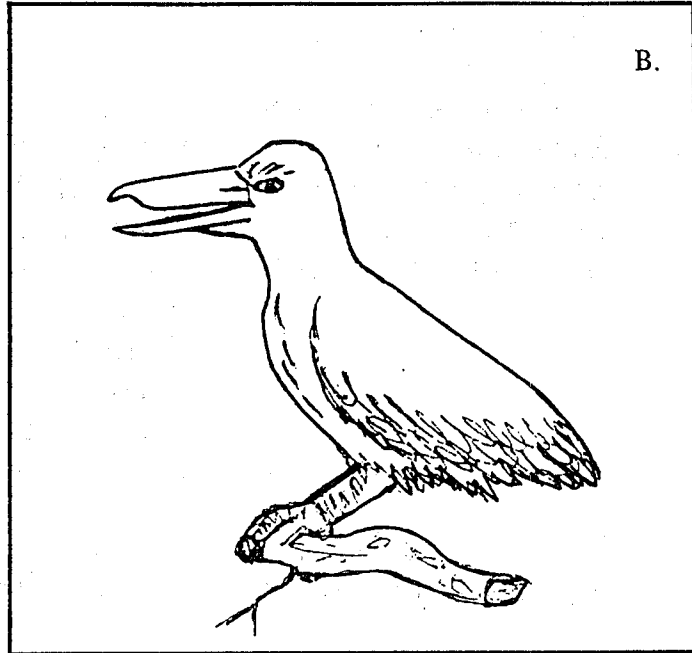
Conclusion

Students soon realise which card type is 'naturally selected' by the conditions of their habitat. (These are the kinds which score their points!) A lot of worthwhile discussion can be generated in follow up.

Example of Bird Cards

TYPE A	Dull green	flies	long beak
TYPE B	Dull green	cannot fly	long beak
TYPE C	Yellow	flies	short beak





ACTIVITIES WITH THE MICROSCOPE (SEN 1983, Vol. 32 No. 3)

Phil Johnson, Evans HS

A. Suitable Material for Use With School Students

MATERIAL	FEATURES Reasons for Observations	METHOD
Tiny letters 'p, 'e' cut from paper	Shows inverted image. Gives practice in focussing under L.P. Slide gives notion of magnification (+100)	Place on slide without cover- slip. Slightly dampen so that letters stick in position. Practise moving slide while observ- ing. L.P. only
Starch grains from potato, soaked beans or wheat grains	Simple preparation. Shows concentric rings under H.P. Practice in adding stain.	Scrape cut surface. Tran- sfer milky smear to slide Stain blue with iodine after initial observation L.P. and H.P.
Tomato, potato or watermelon, fleshy tissue	Easy to see cell wall, round, loosely packed cells, large size.	Thin sliver on slide (no cover slip). Hold up to light. Use hand lens for cell out- lines. Keep moist.
Onion epidermis i.e. skin from inside fleshy bulb	Regular shaped brick- like cells. Vacuoles and nucleus can be seen in some.	Hand lens first, then L.P. and H.P. Make diagram. Stain with red eosin.

Tradescantia
epidermis, from
lower leaf surface
(geranium leaf is
also suitable)

Irregular shaped epi-
dermal cells (like
crazy paving) with scat-
tered stomates, bean
shaped stomates plus
chloroplasts.

Allow leaf to
wilt slightly
before strip-
ping off epi-
dermis piece.
Mount in water
Use L.P. and
H.P. No stain
needed.

Elodea (water weed)
-edge cells of leaf

Chloroplasts easy to see.
If healthy some will be
moving within cell,
indicating streaming of
cytoplasm.

Mount whole
leaf taken
from near stem
tip. Water
only. L.P. H.P.

Spirogyra, an algae
pond scum, green
slime.

Ribbon-like spiral
chloroplast. Chain of
cells joined end to end.
Spiral chloroplasts
enable depth of field
to be judged.

Mount in water
only, using
dissecting
needle to
break strands
and arrange
them on slide.

Transverse section
(T.S.) of young
stem, e.g. geranium
balsam, tomato,
pumpkin or celery
stalk or rhubarb
stalk.

Ring of vascular bundles
(veins) of conducting
tissue. Set in ground
tissue and surrounded
by outer epidermis.
(Balsam has spicules
scattered throughout.)

Thin section
mounted in
water and
eosin to stain
vascular
bundles. Can
be viewed with
hand lens,
then L.P.

Hairs, pumpkin
family (*cucurbita*)
or purple hairs of
stamens of *trades-*
cantia flowers.

Rows of cells tapering
from base. Vacuoles and
nucleus can be seen
(especially in those
near the base)

Mount in water
L.P., H.P. for
a cell near
base.

Human cheek cells (from internal lining epithelium)	Simple shapes. Nucleus and granulated cytoplasm.	Mount in 0.65% salt solution, (water will do for quick viewing), add eosin. L.P. H.P. Take a small scraping with a spatula.
Unicellular organisms of hay infusions, pond water on surface of waterweeds at base of aquarium.	Variety of ciliates, flagellates, diatoms. Succession of organisms in hay infusions.	Drop of cul- ture medium under L.P. (Discard if no organisms are readily vis- ible.) Move- ment may be slowed down with methyl cellulose or saliva.

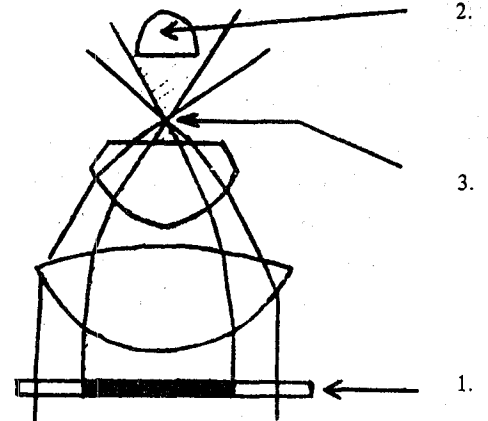
B. Dark Field Technique

Dark field technique aims at improving the contrast of specimen features. The technique is at its best when small transparent objects are to be viewed. They are rendered much easier to perceive because they are made to appear bright against a dark background.

Through the use of a dark field condenser the normal pattern of light and dark are reversed. The background now appears dark and fine structures are seen as pinpoints of light. However, with this technique resolving power is reduced. (This method needs to be used in conjunction with normal microscopic procedures so that a student can gain a more realistic impression of the tissue.)

Essentially, direct light must not reach the objective, but the objective must be able to collect as much as possible of the light scattered by the specimen.

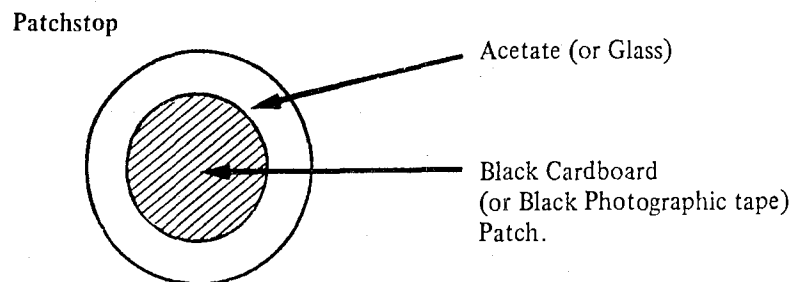
1. Filter holder with central opaque patch. A hollow cone of light is produced.
2. Objective which is inside the dark centre of the cone receives no direct light, i.e. darkfield.
3. Specimen at apex of hollow cone of light reflects and diffracts light which objective can pick up, eg. bright pinpoints of light.



As soon as the objective Numeral Aperture (NA) exceeds the aperture of the cone, direct rays enter the objective and a darkfield effect cannot be obtained. For objectives with Numeral Aperture less than 0.7, an ordinary 1.25 NA condenser can be used to produce darkfield by the addition of a 'patchstop' in the filter of the condenser.

Producing the Patchstop

1. Remove the blue filter from the microscope filter holder.
2. Trace the shape of the filter onto a piece of acetate sheet and cut out the disc of acetate.
3. Check that the disc fits the filter holder.
4. Trace the outline of a one cent coin onto some black paper and cut out the paper disc.
5. Paste the paper disc on the middle of the acetate disc to make the patchstop. (Acetone works as paste.)
6. Place your patchstop on the filter holder.



Procedure

1. Use the blue filter on the lamp and in the microscope holder. Place the test slide of *Pleurosignma angulatum* of your slide of pond water on the stage. You may need to use some methyl cellulose to slow down the organisms in pond water. Focus on the organisms.
2. Remove the slide and place a drop of oil on the top lens of the sub-stage condenser.
3. Replace the slide and raise the condenser until the oil touches the slide.
4. Open the iris diaphragm fully and then view under high power.

Additional Comments

1. Slides and coverslip must be clean. Glare produced by dust or grease reduces contrast of the image.
2. The specimen must be lit at the apex of the cone, i.e. it cannot be too thick or the condenser will not focus the cone of the specimen and no bright points of light will be produced.
3. The patchstop must be carefully centred otherwise there will be uneven intensity of light.
4. A 35mm slide projector can be used as the light source if the image is dark.

This technique is used to bring out spectacular detail in specimens which otherwise have little or no contrast.

C CARE OF THE MICROSCOPE

1. Cleaning dust off lenses

- a) Remove the dust with a camera blower. Ensure that only a blower with a dust cover is used.
Alternatively, just 'huff' on the lens.
- b) The dust can be wiped off (if no grease is present) with one of the following:
 - a well washed handkerchief
 - cotton buds on an orange stick.(Cotton buds are 100% cotton, but cotton wool is up to 80% synthetic and should not be used. Orange sticks, which are obtained from jewellers have no 'grease' in their wood.)

2. Cleaning grease off lenses

The best solvent to use is Shell X-55. This is non-toxic and is obtainable from Olympus. Special dispensing bottles can be obtained from Anax for approximately \$5.

Other solvents which are satisfactory are:

- Windex used with cotton buds
- OPSM Spectacle Lens Cleaner.

3. Removing immersion oil

- a) Initially wipe both objective and condenser with Kleenex or Bowscot Microwipes. The latter are more lint free and it is not necessary to wipe as hard.

Lens tissues are good but are not absorptive enough.

Whatever is used, always dispose of the top sheet which has been collecting dust and chalk.

4. Identifying the position of grit

- a) Eyepiece: Check by rotating the eyepiece. If the grit moves then rotate top end against bottom end to establish whether it is on the bottom or top lens of the eyepiece.

- b) If a square of the ground glass is placed in the system and the grit is still visible, the grit must be on your side of the glass.

Never clean a clean lens.

Never use a solvent unless grease is present.

5. The iris diaphragm

Never lubricate the leaves of the iris diaphragm with oil or grease as the leaves will adhere. Rub a 4B pencil (graphite) on the leaves to 'free' their movement.

N.B. Major problems with other parts of the microscope should not be dealt with by anyone other than a qualified technician.

D PHOTOMICROSCOPY - PHOTOGRAPHY THROUGH THE MICROSCOPE

Photomicrographs similar to those supplied to schools as a strip film may be taken using the microscope issued to schools. A single lens reflex camera with through-the-lens metering makes the task easy. The skill lies in the use of the microscope rather than in photographic expertise.

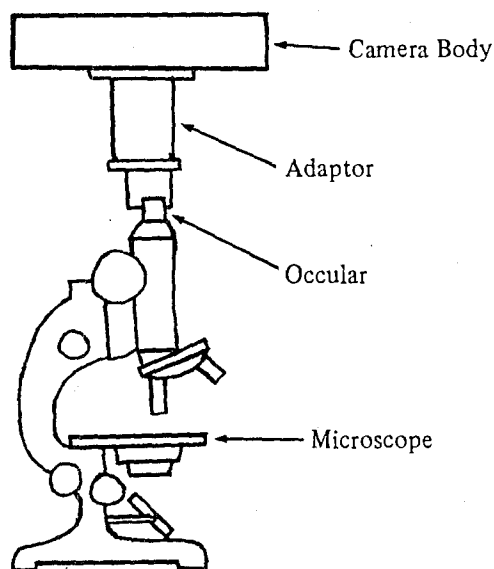
Usefulness

The advantage of using a camera to record data and observations are:

1. The student has a permanent record for notes and/or measurements.
2. The teacher is able to ensure that the student has observed the required features of the slide.
3. The best slides produced by members of the class can be shown to and discussed by the entire class.
4. A record of slides produced can be built up by the teacher for use in the following years.

What is needed

1. A 35mm SLR camera. This needs to have a through-the-lens metering. Other types of camera can be used but will require a trial and error approach.
2. A microscope of a type currently issued to schools.
3. A microscope adaptor. The adaptor needs to fit the camera when the lens is removed and be able to be mounted on a school microscope. You may have to purchase this piece of equipment yourself. They cost around \$50.
4. Artificial light Ektachrome film - EPY 135.
5. One blue filter for microscope. (Needed to remove yellow tinge from light.)



GENERAL SET-UP

Setting up the Equipment

1. The adaptor is fitted to the microscope by removing the eyepiece, fitting the adaptor over the barrel of the microscope and replacing the eyepiece. The 10X eyepiece gives the best results as it forms an image which completely fills a 35mm negative.
2. The camera body is now fitted to the adaptor.
3. A suitable source of light is provided by a slide projector. A piece of ground glass between the projector and the microscope acts as a diffuser. The iris diaphragm of the condenser can be used to control light intensity. The diaphragm is adjusted so that the metering system indicates the correct intensity. If a transformer is used the setting once set should not be changed.
4. Colour film can be used for almost any material. Suitable films will have an ASA rating of less than 125, where a slide projector is used as the source of light. These films have a finer grain which permits further enlargement. If artificial light film is used a blue filter should be used on the microscope.

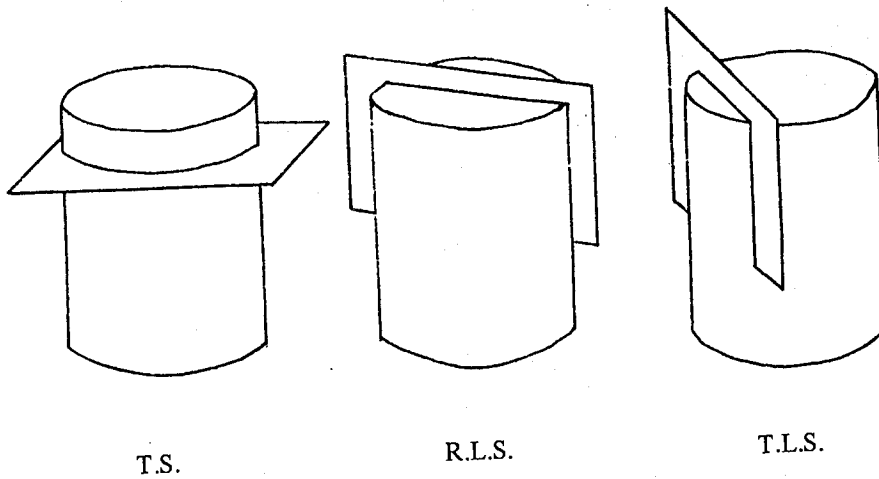
Problems

1. In some cameras the ground glass screen used for focussing the image is rough. This makes the image detail poor but only in the image which must be used for focussing. The photomicrograph will turn out fine. The Olympus OM has a special clear focussing screen.
2. The edges of the slide may be out of focus. This is due to the convex lens in the objective and is more noticeable at high magnification.
3. The light may not be evenly distributed with the edges darker than the centre. This is also due to the convex lens in the objective.
4. The circular field of view of the microscope can result in dark corners in the slide. This is more noticeable at low magnification.

E. SECTIONING

The structure of plant organs such as roots, stems and leaves can be determined by cutting sections, staining and examining them under the microscope.

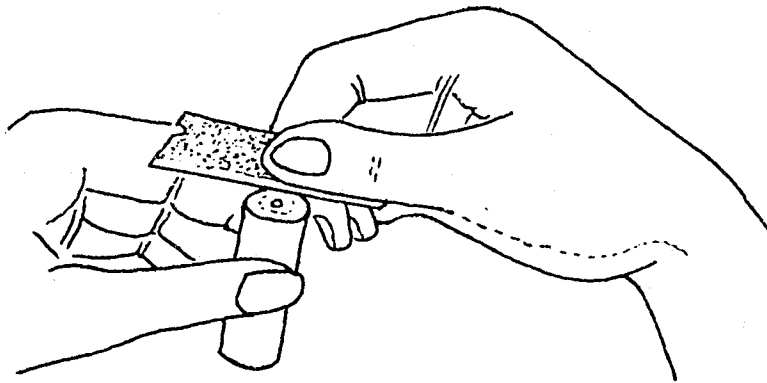
For general purposes, the most useful sections are:



Cutting Transverse Sections

1. From thick material:

- a) Take a piece of organ about 2cm long; carefully make one transverse cut. This gives you a 'true' surface to cut from.
- b) Hold the specimen upright firmly between your thumb and forefinger and cut thin slices from the surface using a **new** single-edged razor blade. Cut towards you.



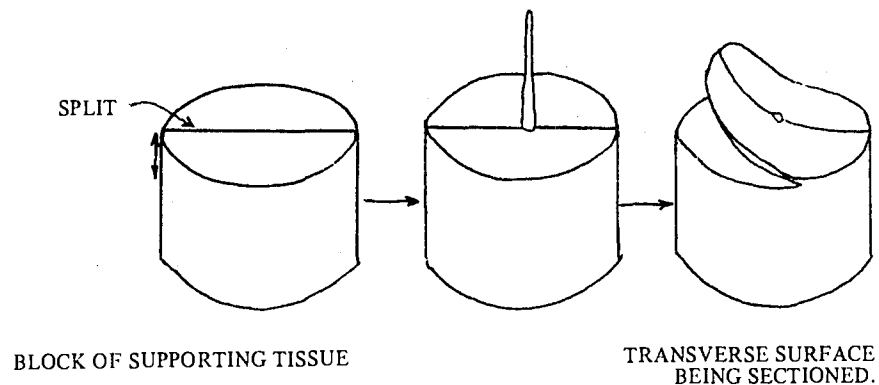
- c) Keep the blade and specimen wet during sectioning.
- d) Transfer the sections to water (using a fine brush) as you cut them. Make several sections and then choose the thinnest for study.
- e) The transverse surface will have to be retrimmed frequently to avoid oblique sections which are

totally unsuitable. (In an oblique section the cell outlines are not clearly defined and will often appear as parallel streaks, making interpretation extremely difficult.)

2. From thin material:

Method 1

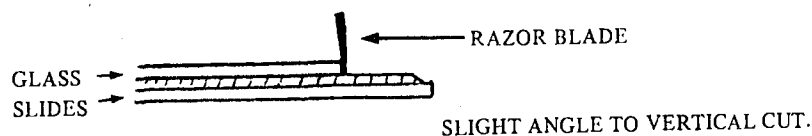
- a) Prepare a small block of supporting tissue (piece of carrot root, potato tuber or foam).
- b) Split the block or remove a narrow wedge of tissue from the block.
- c) Place the specimen to be sectioned in the supporting block.
- d) Hold the block firmly and section **both** it and the specimen.



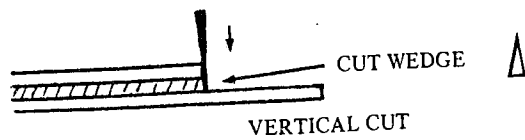
- * Entire sections are not necessary. Since plant organs are often symmetrical, a portion of the organ should allow you to interpret its structure.

Method 2

- a) Place the material to be sectioned between two glass slides.
- b) Move the top slide back to expose the material and then cut at a slight angle to the vertical.

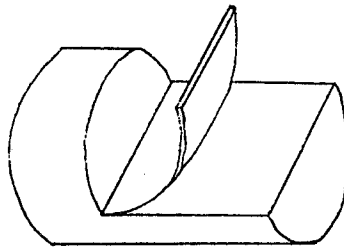


- c) Make a second cut perpendicular to the slide. This will form a wedge of material which should be very thin on one edge.

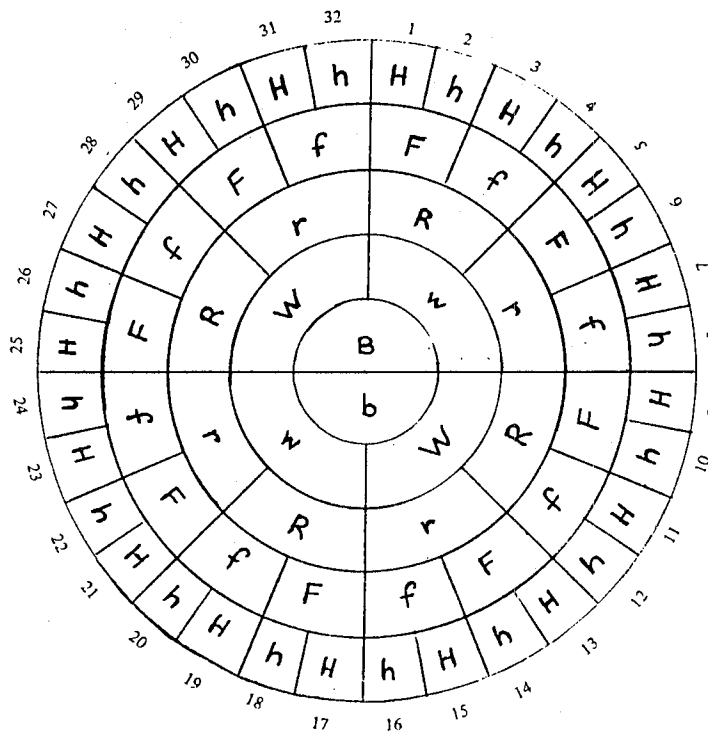


Cutting a Longitudinal Section

Prepare a longitudinal surface as shown in the figure and section from this surface, retrimming frequently.



GENETICS WHEEL (SEN 1983, Vol. 32 No. 4)



KEY

B	= non-blue eyes;	b	= blue eyes.
W	= widow's peak;	w	= straight hairline.
R	= can roll tongue;	r	= cannot roll tongue.
F	= unfused ear lobes;	f	= fused ear lobes.
H	= hair between first and second finger joints;		
h	= no hair between first and second finger joints.		

Start at the centre of the wheel. Shade in the semi-circle that describes the characteristic that you have. From the shaded area move to the area in the next circle that applies to you and shade it. Continue this process until you have shaded a section of the outermost circle.

Some Questions

1. What number did you reach at the outside of the wheel?
2. How many people reached the same number as you?
3. Which number did most people in the class end up at?
4. We have considered only five characteristics of people.
Do you think fewer people would end up at the same number if fewer characteristics were considered? Why?
5. Can you think of cases where two people do have the same form of all their features? Why are they so similar?

THE KIDNEY - A SCRIPTED ROLE PLAY (SEN 1984, Vol. 33. No. 4)
Julie Crowley, North Sydney PSC

We all learn best by active involvement in the learning process. Here is a role play I have used effectively with senior biology students. It involves a minimum of preparation and no movement of classroom equipment.

Equipment

1. Cards entitled: -
 - red blood cell
 - large protein molecule
 - water molecule
 - sodium ion
 - amino acid
 - nitrogenous waste material.
2. Signs to set the scene, to be arranged around the room in a logical sequence such as:
 - renal artery
 - to the nephron
 - glomerulus
 - to loop of Henle
 - ureter, to the bladder
 - renal vein.
3. Script

I am -----, travelling in the blood. I travel in the renal artery and enter the kidney. Finally I come to a nephron and into a glomerulus.

Ending 1. I stay in the capillary and finally join the renal vein and leave the kidney.

Ending 2. I am filtered out of the blood and go long a long twisted tube. The tube goes into the loop of Henle and I am reabsorbed into the capillaries. I finally reach the renal vein and leave the kidney.

Ending 3. I am filtered out of the blood and go along a long twisted tube. The tube goes into the loop of Henle and I join a collecting tube which finally becomes the ureter. The ureter takes me to the bladder. I pass out of the body as urine.

Procedure

One student collects a card and enters the 'kidney'. As the student reads their script they move around the 'kidney'. The role play involves a choice of three endings. The student must decide which ending to choose for their card and so must be actively involved in the experience.

The rest of the class can follow on their scripts. The role play can be stopped so that other students can think about which ending they would choose and then check answers at the conclusion.

I feel that it reinforces the exercise to have the students moving to the appropriate part of the room as they read their script. Students could make up their own scripts on the action of other organs for homework.

CRAFTY SCIENCE. THE ART AND CRAFT AND SCIENCE SHOW? (SEN 1986, Vol. 35 No. 2)

Margaret Ruckert

For any craft there is generally a large back up of scientific facts and procedures. In pottery, a knowledge and appreciation of the type of clay, together with the different effects of chemical glazes and firing, is used to create the finished product. The potter is both a material scientist and artist; cause and effect are constantly being monitored.

We hear about a revival of interest in the crafts. Local art and craft shows are popular. But have the crafts ever been neglected? I suspect the human need for self-expression and the satisfaction gained from mastery over materials is always present. How can we revive dormant student desires and use them in active learning situations in ecology, for example?

The HSC Biology syllabus section, Ecology, states one of its aims is 'to develop an appreciation of the wide variety of ecosystems'. I felt students were bored of botanical names and bewildered at the huge scale of plant communities. So I decided to reduce the complexity to a size that could be appreciated - into a basket!

The Bush Basket

Materials

- * small basket - mine was 8cm diameter
- * 'mechanic' to fill it, e.g. Secbrick or Oasis
- * optional chicken wire, piece of thin wire
- * plant species
- * ribbon and piece of paper for scroll.

Before the Lesson

1. Collect samples of the major species that occur in the dry sclerophyll forest, e.g. Eucalyptus fruits and flowers, Banksia leaves (cones and leaves of some species are too large to use in the basket but could be demonstrated), Leptospermum sp., Acacia or daisy sp., Melaleuca or Callistemon spikes, bracken fern. For simplicity, have only one white flower, one yellow flower, etc. or students will get them mixed up.

OR

2. Air dry by hanging upside down for two weeks. Buy suitable specimens for use from homemaker shops. The basket looks drab with mainly brown plants, so buy some yellow daisy anyway.
3. Cut Secbrick to fit the basket and slightly higher than the top of it and push down firmly. For larger baskets a piece of chicken wire on the top, held down by a wire wrapped around both handles will keep the 'mechanic' in place better.

The Lesson

1. Describe the dry sclerophyll environment and illustrate with large specimens of the dried plants. Discuss adaptive features. Discuss the plan of the basket and draw the plan on the board.

Teacher Demonstration

1. Have a slightly larger basket than the students. Fill with Secbrick.
2. Start from the outside and place small fern pieces hanging over the edge to hide the 'mechanic'. (If you press the fern you get the best effect.)
3. Make a circle of Eucalyptus fruits next to the edge of the basket. Stems will be about 6cm long.
4. Make a star of daisy or wattle flowers approximately 5cm long.
5. Fill in the points with Leptospermum approximately 7cm long.
6. Place a few spikes of Callistemon radiating out from the centre approximately 12cm long.
7. Assess where more filling is required and use cut down Banksia leaves.

Making the Scroll of Adaptations

Students identify each plant and write up their scroll.

Plan	My Basket
------	-----------

Plant	Adaptations
-------	-------------

- 1.
- 2.
- 3.

Put in a safe place while the next activity is going on.

Filling the Basket

Make sure students follow the plan or a jumble results. Start from the outside and work in. Tie on the scroll.

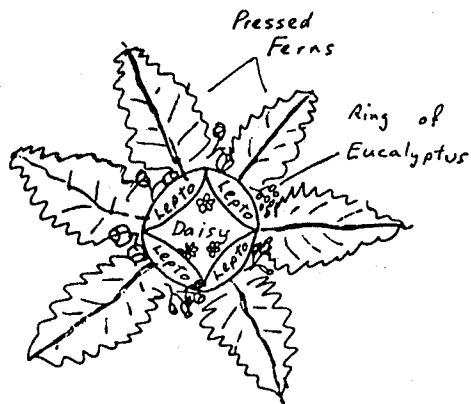
Results

Each student has their own piece of Australian 'bush' to study and admire each day. By the end of the lesson you will find them using plant names as they work their basket.

Follow Up - The Endless Collection

Make a collection of seeds, seed pods and fruits. Buy a small box and decorate the lid. Inside place specimens and a list of contents together with relevant botanical explanations.

Note: Of course the more motivated student can start his/her own mini-herbarium using pressed specimens. But how often are they looked at or memorised?



THE ARBITRARY NATURE OF CLASSIFICATION (SEN 1987, Vol. 36 No. 3)

Joan Williams, St Johns Park HS

The following information can be used to cover the section dealing with the arbitrary nature of classification in the Biology syllabus. The detail included here may be more than the minimum requirement for the core but it illustrates the concept well. Additional information for teachers can be found in A Guide to Invertebrate Animals (second edition), Webb, Wallwork and Elgood, Macmillan Education, pp. 104-115, 128-131 and 152-163.

Since classification is designed by humans it is likely to change as new evidence becomes available or if different criteria are used.

Examples

*** Fungi**

Fungi were once classified in the plant kingdom because of features like their sedentary habit, cell wall and reproduction by spores. More recently the criteria for being a plant were restricted to organisms containing chloroplasts, thus being autotrophic. This excluded fungi as they are heterotrophs. Fungi are now placed in a kingdom of their own.

*** Arthropods.**

In the last 10 years or so, some biologists have found that evidence from evolutionary trends and embryology suggest that this group should really be three phyla. This difference of opinion is the result of new evidence and the use of different criteria.

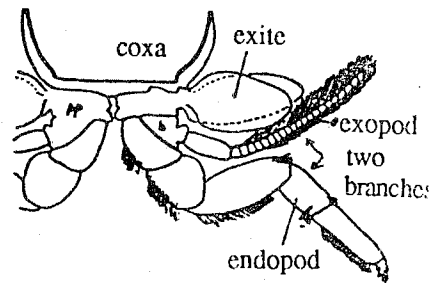
PHYLUM	SUB-PHYLUM	EXAMPLE
CRUSTACEA	thoracognatha maxillopoda malacostraca ostracoda	<i>daphnia</i> , the water flea <i>lepas</i> , the barnacle <i>metapenaeus</i> , the prawn
CHELICERATA	class merostomata class arachnida class pycnogonida	<i>limulus</i> , the kingcrab spiders sea spiders
UNIRAMIA	onychophora myriapoda hexapoda	<i>peripatus</i> centipedes, millipedes insects

PHYLUM CRUSTACEA

- a) mainly aquatic
- b) two pairs of antennae
- c) branched limbs - usually biramous (two branches)
- d) jaws have evolved from the bases of the limbs

pp = protopod

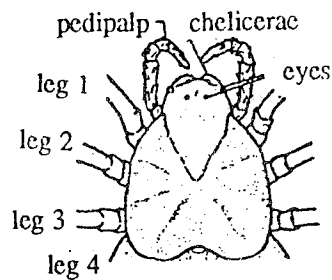
b = basis



T.S. The biramous limb, the thoracic limb of a crustacean

PHYLUM CHELICERATA

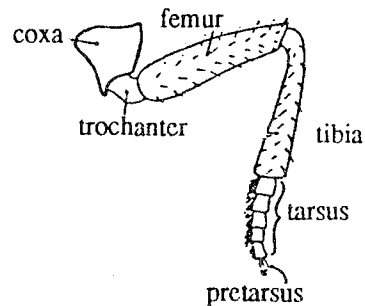
- a) no antennae
- b) evolved from a biramous limbed ancestor
- c) jaws evolved from the bases of the limbs
- d) two pairs of feeding appendages attached to the head, i.e. the chelicera and the pedipalp



Dorsal view of head and thorax of a spider

PHYLUM UNIRAMIA

- a) mainly terrestrial
- b) one pair of antennae
- c) limbs are unbranched, i.e. uniramous
- d) jaws have evolved from whole limbs
- e) embryonic development shows common ancestry with annelids.



The uniramous limb of an insect

**HERE'S HOW YOU
CAN DO IT
IN
CHEMISTRY**

Section 2.

HERES HOW YOU CAN DO IT IN CHEMISTRY

CONTENTS

The Extraction of Useful Substances from the Earth	1
Practical Examination: Identification of an Unknown Compound	6
Preparation of Ethanol by Fermentation	8
The Densities of Analine and Water	1 0
A Coloured Clock Reaction	1 1
The Size of a Molecule	1 3
Avogadro's Number: Determination Using a Monolayer	1 4
A Cheap Selective-Ion Electrode	1 5
Hydrogen Power?	1 8
Instant Gel	2 0
Energy from Chemicals	2 1
The Fountain Experiment	2 3
Catalysis, A Transition Metal and Oxidation Reduction	2 5
Comparative Abundance of the Elements	2 7
Colourful Chemical Demonstrations	2 9

Demonstrating Guy-Lussac's Law	3 4
Confusion over Diffusion	4 2
A Gas Sampling Device	4 4
Soap Making - An Alternative Recipe that Works	4 5
Some Interesting Demonstrations	4 6
Demonstration Diaphragm Cell for the Electrolytic Production of Sodium Hydroxide	4 7
The Rising Suds	4 8
Making a Breathalyser	4 9
Some Experiments on Equilibrium	5 0
Solar Energy Storage: A Demonstration	5 3
Chemical Magic, Based on the Clock Reaction	5 4
An Oxidation Reaction: 1-Propanol to Propanol	5 6
The Preparation of Benzoic Acid from Benzyl Chloride	5 9
Hydrolysis of the Ester Methyl Salicylate	6 0
Using a Dissecting Microscope in Teaching Introductory Chemistry	6 1
Removal of Colloidal Silver Stains	6 4
Burning Magnesium in Dry Ice	6 7

**THE EXTRACTION OF USEFUL SUBSTANCES FROM THE EARTH (SEN
1979, Vol. 28 No. 1)
Dr G.W. Thickett, Belmore BHS**

The following article is part of an address delivered at an inservice conference held at Belmore Boys' High School. This extract is a developmental sequence for a Year 7 chemistry unit which has been developed on the theme of extraction of useful substances from the earth.

Extraction of Useful Substances from the Earth

Period	Major Idea	Developmental Sequence
1,2	Extraction of metals from natural ores	<ol style="list-style-type: none">1. Certain substances are found in their native state in the earth. Gold and silver.2. Fascination of people with gold and silver from earliest times - used in ornaments.3. Recognition by ancient tribes of copper and copper bearing ores. Extraction of these ores using heat and charcoal.4. Lab experiment on the extraction of copper from copper carbonate on a carbon block.
3.	Physical properties of copper	Students discover the following properties of copper: <ol style="list-style-type: none">1. colour, lustre2. malleability, ductility, hardness3. conductivity of heat and electricity.
4,5	Chemical properties of copper	Students examine some chemical properties of copper: <ol style="list-style-type: none">1. not attacked or corroded by hot water or cold water2. forms a black, scaly coating when heated in a bunsen flame

3. copper colours a bunsen flame green.

Properties (both physical and chemical) are summarised - students made aware of how these properties make Cu useful for water pipes and electrical wiring.

6,7 Preparation of copper oxide, carbon block decomposition of black oxide to Cu

Students heat strips of Cu sheet in a bunsen and scrape off and collect black scale. Process is repeated to obtain sufficient oxide for use on the carbon block. The black material is decomposed back to Cu on a carbon block. Students summarise these ideas:

coppergas (O_2) combines

copperoxide forming black scale

8,9 Iron in the natural state

Meteoric iron. Ores containing iron. Colours of ores. Early people discover how to extract iron - charcoal and high temperatures. Iron ores in Australia

- mining sites
- processing sites.

10,11 Can iron ore be decomposed into iron in the lab?

Students attempt to reduce Fe_2O_3 to Fe on a carbon block. By their failure, they see the requirement for higher temperature.

The blast furnace

Blast furnace operation examined simply along the following lines:

- temperature required
- need for coke
- limestone removes unwanted wastes from ore.

12 Properties of iron (1)

Physical properties examined as per copper:

- lustre, colour, malleability, ductility
- electrical/heat conductivity
- comparison of heat conductivity of iron and copper

13,14, 15	Properties of iron (2)	<p>Chemical tests on iron:</p> <ol style="list-style-type: none"> effect of cold/hot water over <ol style="list-style-type: none"> the short term the long term experiment set up to show the requirement for air and water in rusting burning of iron wool to produce a grey-black substance - students reminded of a similar effect with copper. New substance is an iron oxide.
16	Removal of oxygen from the air during rusting	<p>Moist steel wool removes 20% of the air as it rusts (as revealed by a rise in water level when the experiment is conducted in a closed tube over water. As the iron rusts, a type of iron oxide forms: $\text{iron} + \text{gas in the air} \rightarrow \text{iron oxide}$ Students encouraged to see that air contains 20% by volume of a reactive gas called oxygen.</p>
17	Combustion - the experiments of Priestley and Lavoisier	<p>Rusting experiment compared with Priestley's and Lavoisier's experiments with mercury and mercury calx. Burning involves combination of the metal with 20% of the air (oxygen). Ores of mercury (cinnabar) mentioned.</p>
18	Summary of ideas	<p>Students revise the following ideas</p> <ol style="list-style-type: none"> metals can be extracted from their ores by heating; heating can cause the ore to break down to release the metal, under certain conditions mercury and copper are released more easily from their ores than iron
19	Summary of ideas (continued)	<ol style="list-style-type: none"> metals can be made to react with the oxygen in the air to produce new substances called oxides; some metal oxides are

		found naturally as ores (eg. iron oxide in iron ore)
		d) metal oxides can be decomposed back to the metal and oxygen under certain conditions; some oxides (such as mercury oxide) are more easily decomposed than others (eg. iron oxide).
20,21	Methods of extraction of naturally occurring substances without changing them	Salt is reviewed as being of major importance to all - now and in the past; salt valued and used as money, salt required for our diet; mining of salt; salt extraction from the sea; large scale methods.
22,23	Laboratory evaporation of sea water	Students study the techniques involved in evaporation of salt water; names of equipment; reasons behind evaporation technique involving separation on the basis of differing BPs; crystals form; fast and slow evaporation.
24,25	Distillation to obtain fresh water	Concept of distillation, involving evaporation and condensation; apparatus required; students distil salt water, collect distillate and evaporate a little distillate on glass slide to check that no salt is present ((do a control with a drop of salt water).
26,27	Distillation of water containing mud and salt	Students note that both the mud and salt remain behind in the distillation flask, only the low BP water is distilled; large scale distillations in industry, eg. petrol and wine; ideas of fractional distillation based on differing BPs
28,29	Filtration	Ideas of solubility as a criterion for filtration; industrial examples of uses of filtration; students filter a suspension of iron oxide

in water; equipment and techniques examined.

30,31 Ideas of insolubility

1. Students test the solubility of each of the following in water:
 - copper oxide, iron oxide, sugar, bicarbonate of soda.
2. On the basis of solubility results students design an experiment to separate a solid mixture of sugar and copper oxide.
3. Experiment is performed using the techniques of filtration and evaporation; methods of growing large crystals examined.

32 Review

Students review the main ideas of the unit:

1. We obtain useful substances from the earth via -
 - a) chemical decomposition methods, eg. heating, heating with carbon; some ores are more easily extracted than others, eg. cinnabar and malachite are more easily decomposed than iron ore
 - b) physical separation methods (which do not alter the material), eg. evaporation, distillation, filtration.
2. Metals when heated with oxygen of the air combine with it to form new substances called metal oxides. Metal oxides can be decomposed under certain conditions to form the metal once more. The oxygen is then driven off.

PRACTICAL EXAMINATION: IDENTIFICATION OF AN UNKNOWN COMPOUND (SEN 1979, Vol. 28 No. 4)

Geoffrey Thickett, Belmore BHS

INTRODUCTION

The following experiment is useful as both a practical examination and an exercise in developing manipulative proficiency. CYCLOHEXANE is the best unknown to use with its melting and boiling points being sharp and readily measurable in a school laboratory. Benzene is NOT recommended owing to its toxicity. Other alternatives include 2-methyl 2-propanol and cyclohexanol.

Aim

To identify an unknown organic compound by determining its density, melting point and boiling point.

Background

In this exercise it is vital that the determination be performed accurately. Once the data has been collected, reference is made to the accompanying table of chemical data in order to identify the unknown.

Procedure

A. Density Determination

1. Determine the mass of a clean, dry 10mL measuring cylinder on a sliding poise balance. Record this mass.
2. Remove the measuring cylinder from the balance pan and add (with the aid of a dropper) the unknown liquid to the cylinder until the volume is exactly 10.0mL (bottom of meniscus). (V)
3. Determine the mass of the cylinder plus the unknown liquid. Thus calculate the mass of the 10.0mL of the unknown. (m)
4. Calculate the density of the unknown liquid using the formula
$$D = m/V \text{ (g.mL}^{-1}\text{)}$$

B. Boiling Point Determination

1. Set up the quickfit apparatus as directed and ensure that there is no strain placed on the joints. The distillation flask is heated by a surrounding water bath. The unknown is highly flammable and bunsen flames **must not** be brought near it or its vapours. Ensure that water is flowing through the condenser jacket throughout the distillation.
2. Pour the 10mL of unknown from Part A into the distillation flask and use your hot water bath as a source of heat. The thermometer bulb should be about 1cm above the surface of the boiling liquid. Distil at a constant rate and record the thermometer reading every minute from the beginning of the experiment until distillation is

complete. Remember that a constant temperature reading is an indication of the boiling point.

3. Plot a graph of temperature versus time and determine the boiling point from the graph.

C. Melting Point Determination

1. Insert a thermometer in the test tube of distillate collected in Part B. Place the tube in an ice water bath or refrigerator until the unknown has completely solidified and the thermometer reads 2°C or less.
2. At time zero, remove the tube from the ice bath and place it in a test tube rack to warm up. Measure and record the temperature every minute until the temperature rises about 5°C above the melting point. Return the unknown liquid to the front bench. Do not discard.
3. Plot a graph of temperature versus time and indicate on the graph the melting point of the unknown.

Treatment of Data

Use the three pieces of experimental data to identify the unknown from the list of possibilities supplied. In your report you should list all the possibilities and systematically eliminate them, giving your reasons. Remember that all your data may not be as accurate as you think. Name the unknown, give its molecular formula and draw its graphic formula.

DATA SHEET

Name	Density (g/mL)	MP (°C)	BP (°C)
Hexadecane $C_{14}H_{34}$	0.774	18.52	87.5
Tribromomethane $CHBr_3$	2.890	8.3	149.6
Dibromomethane $C_2H_4Br_2$	2.180	10.0	131.7
2-methyl-2-propanol $C_4H_{10}O$	0.786	25	82.5
3-methyl-2-butanol $C_5H_{10}O$	0.818	171	12.9
Cyclohexanol $C_6H_{12}O$	0.962	25.5	161.1
Cyclohexane C_6H_{12}	0.779	6.5	80.7
Methanoic acid CH_2O_2	1.2203	8.4	100.9
Benzene C_6H_6	0.879	5.5	80.1
Ethyl acetate $C_4H_8O_2$	0.901	-83.6	77.2
Ethanol C_2H_6O	0.789	-114.5	78.5
Cyclohexene C_6H_{10}	0.810	-103.7	83.3
2-propanol C_3H_8O	0.785	-89.5	82.4
Butanone C_4H_8O	0.815	-86.9	79.5
Nitrobenzene $C_6H_5NO_2$	1.203	5.7	210.9

PREPARATION OF ETHANOL BY FERMENTATION (SEN 1980, Vol. 29 No. 2)

Rees Bunker, Heathcote HS

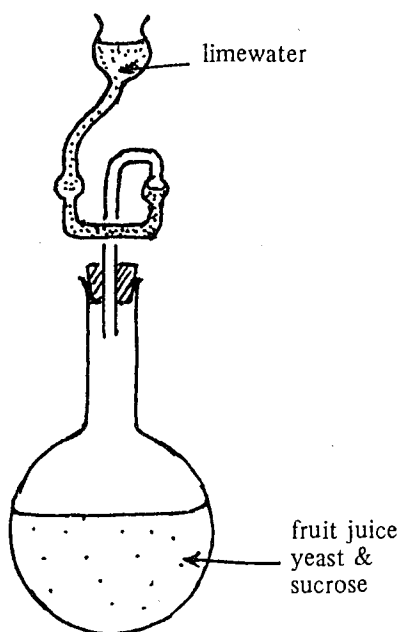
Introduction

When grain, tubers and fruit ferment, the carbohydrates in them are converted by a series of reactions into ethanol, $\text{CH}_3\text{CH}_2\text{OH}$. Various enzymes contained in yeast speed up the reactions involved.

Method

To a 370mL can of pure fruit juice, add 20g of sucrose and one packet of dried yeast or 2g of compressed yeast. Put this mixture into a 500mL flask sealed with a modified thistle funnel as shown in Figure 1, or with a piece of rubber tubing submerged in a beaker of water. Allow to stand for 2-5 days in a warm atmosphere. the temperature should be 25-35°C.

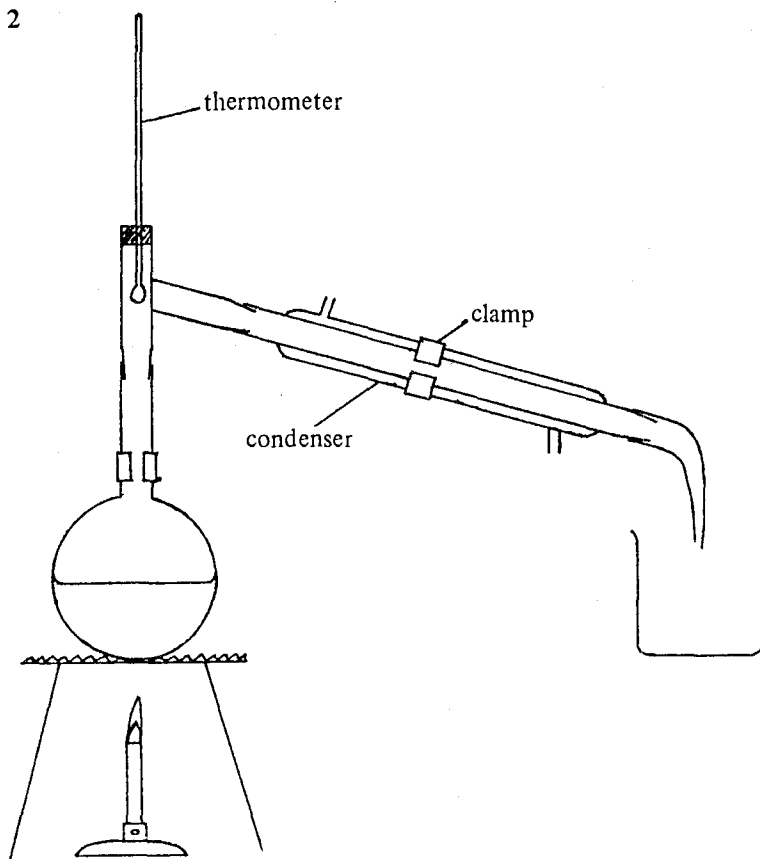
FIG. 1



Decant the liquid without disturbing the yeast and filter through cotton wool if required. Carefully distil this aqueous solution as shown in Figure 2. **Caution:** much frothing may occur at first, so heat cautiously. Note the temperature at which the distillate passes over.

Collect the distillate until the temperature rises above 97°C. Place the distillate in an evaporating basin and ignite with a burning splint. What is the colour of the flame? If the distillate does not ignite then redistill it with the temperature reaching no more than 85°C. Remove any remaining water by allowing to stand overnight in a stoppered flask containing some calcium oxide.

FIG. 2



Questions

1. Why is it important to control the temperature?
2. What type of gas is evolved by the fermentation process?
3. What properties of ethanol were you able to observe?
4. Comment on any differences between the odours of the first and second distillates (if prepared).
5. Write an overall equation for the reaction of the sucrose $C_{12}H_{22}O_{11}$ in the formation of ethanol.
6. What is the equation for the burning of ethanol?
7. Describe some important industrial uses of ethanol.
8. Alcohol is a prime factor in a major portion of cases of human death and misfortune, for example road accidents, sclerosis of the liver, crime and violence, marital disharmony and family breakdown. In the 1920s the United States government introduced prohibition of alcohol for a period in an attempt to reduce the harmful effects of alcohol on the community. Consider the possible effects of a similar prohibition in Australia. Summarise the arguments for and against such a step.

While performing the well known demonstration of the differing expansion coefficients of water and aniline recently, I thought of a new approach.

Instead of adding the cold aniline from the burette to cold water in a 500mL beaker, watching it sink and then heating with a bunsen burner to observe the magic temperature when the densities of the two liquids becomes the same and the spherules hang weightless, I thought out the following variations which do not require the heating of aniline.

Add a drop or two of aniline to a 500mL beaker, half filled with water and then dissolve sufficient sodium chloride to make the aniline float. Now carefully pour the cold water onto a floating cork in the beaker, thus establishing a density gradient up the beaker, the aniline spherules, of course, now hang weightless at the level where their densities are the same as salt water.

Now adjust the burette orifice to the level of the suspended spherules and carefully open the tap. A weightless aniline sphere now grows and more aniline can be added to the burette if required.

Using this method I have grown spherules up to 100mm in diameter before running out of aniline, which is removed afterwards using a separating funnel.

On completion of the above, which takes about five minutes, class discussion is almost limitless, covering density, Archimedes' Principle, weightlessness in space, surface tension, the shape of the earth (the 'sphere' is not in fact spherical), the solubility of so called immiscible liquids, expansion coefficients and Stokes' Law (viscosity).

All the students to whom I have shown this demonstration have been fascinated and I have even been offered money to buy more aniline and hence produce even larger spheres!

(Reprinted from SEN 1970, Vol. 19 No. 3.)

A COLOURED CLOCK REACTION (SEN 1980, Vol. 29 No. 3)

A.J. Sperring and R.C. Warren, Sydney Teachers' College

Concepts: Uses

Rates of reaction; stepwise reactions; change of pH during a reaction; as a colourful demonstration during science fairs, open days, etc.

Materials

Sodium metabisulfite - 20g
sodium sulfite (anhydrous) - 3g
formalin - 90mL
indicators e.g. phenolphthalein
universal indicator
250mL beakers - two or more
white background.

Preparation

- * Solution A: 20g $\text{Na}_2\text{S}_2\text{O}_5$
3g Na_2SO_3
1000mL water.
Dilute this solution by four to give Solution A.
- * Solution B: 90mL formalin
910mL water.

Procedure

1. Mix equal volumes of Solutions A and B thoroughly, after adding about 2mL of indicator solution to one of them.
2. Stand the mixture against a white background.
As a variation, or in studies of the effect of temperature on reaction rate, the above procedure can be repeated after heating one or both of the solutions in a water bath. Heating one solution to about 20°C above room temperature approximately doubles the rate of reaction.

Observations

If the two solutions are mixed thoroughly, a homogeneous colour change should occur after an initial induction period. With phenolphthalein the colour change is from colourless to red; with universal indicator a sequence of colour changes occurs, at a varying rate.

With insufficient mixing the colour change occurs in splotches (itself an arresting phenomenon).

The colour change is not as sharp as in the familiar iodate-sulfite clock reaction, though it is still reasonably rapid.

Comments

The reaction mechanism is:

1. $\text{HCOH} + \text{HSO}_3^- \text{ --- slow } \longrightarrow \text{CH}_2\text{OSO}_3^-$
2. $\text{HCHO} + \text{H}_2\text{O} + \text{SO}_3^{2-} \text{ --- fast } \longrightarrow \text{CH}_2\text{OSO}_3^- + \text{OH}^-$
3. $\text{OH}^- + \text{HSO}_3^- \text{ --- slow } \longrightarrow \text{SO}_3^{2-} + \text{H}_2\text{O}$
4. $\text{OH}^- + \text{indicator} \text{ --- fast } \longrightarrow \text{colour change}$

Colour change is due to the production of OH^- and its reaction with the indicator. However, OH^- is not 'available' for reaction with the indicator until the HSO_3^- has been used up.

THE SIZE OF A MOLECULE (SEN 1980, Vol. 29 No. 4)

R.P. Jones, Macintyre HS

Aim

To determine the order of magnitude of the size of a molecule.

Method

Take a **very** large tray. the wooden tray from a laboratory trolley is only just big enough. Much better, but requiring a little more sense of adventure, is to use the vinyl-tiled floor of the laboratory and build a circular plasticine dam wall about one metre in diameter. Now pour sufficient water in the tray or within your plasticine dam to fill it to about 1cm depth. Now wait awhile. Before the next step the water must be perfectly still. (If you think this is crazy so far, wait till I tell you the next step!)

From a great height, very lightly dust the surface of the water with talcum powder - no, don't overdo it - you only need sufficient talcum dust to make the surface of the water visible.

Now take the thinnest whisker from the laboratory cleaner's straw broom! (Yeah, you're convinced I'm mad - but hang in there - this really works!) This is the tricky part. Dip the fine straw into a bottle of oleic acid and withdraw it at just the right speed so that, when clear of the bottle, just **one** small drop of oleic acid falls off the end of the straw. (This takes some skill, we don't want a stream of drops, just **one**) When you have mastered this technique (in front of the class), repeat it over the centre of the dusty water so that just one tiny drop of oleic acid falls onto the surface.

ZAROOM!!! the effect is mind boggling!

Calculations

All I am going to tell you is that the volume of a drop 1mm in diameter equals the volume of a circular monolayer. You take it from there.

Comments

This is a spectacular experiment and the calculations yield about 10^{-9}m for the size of a molecule, which is right on target. If you have never seen it done before, then go for a dummy run before you spring it on the class. Oh, and by the way, if you want to repeat it you must start with fresh water and talcum all over again. You can't use the same trayful.

AVOGADRO'S NUMBER: DETERMINATION USING A MONOLAYER

(SEN 1982, Vol. 31 No. 2)

Di Herford, St. Claires College, Waverley

Experimental details are outlined in *Chemical Science Teachers Manual* p.14 (and above). Instead of using ethanol as the solvent, ether may be used as the solvent for oleic acid. Here is an outline for the calculations, using the results of some students.

Molar mass of oleic acid = 282
Mass of 1mL of oleic acid = 0.82g
 \therefore number of moles/mL of **pure** oleic acid = 2.91×10^{-3} moles/mL
Diluted oleic acid solution 54 drops = 1.2mL
 \therefore volume of one drop = 2.22×10^{-2} mL
Dilution of oleic acid = 1 in 20
 \therefore volume of **pure** oleic acid used = 1.11×10^{-3} mL in 1 drop
Number of moles of oleic acid used = 3.23×10^{-3} moles
Volume of oleic acid used will be the same as the volume of the monolayer.

Volume of the monolayer:

Diameter of the monolayer = 43cm
Radius of the monolayer = 21.5cm
Assume the monolayer has the shape of a cylinder, $V = \pi r^2 h$
Diameter of one molecule = height of cylinder
 $h = V / \pi r^2$
= 7.46×10^{-7} cm
Radius of one molecule = 3.82×10^{-7} cm
Volume of one molecule = $4/3 \pi r^3$
= 2.335×10^{-19} cm³
 \therefore number of molecules in the monolayer = volume of monolayer
volume of one molecule
= 1.11×10^{-3}
 2.33×10^{-19}
= 4.75×10^{15}
Number of molecules/mole = $4.75 \times 10^{15} = 1.47 \times 10^{21}$
 3.23×10^{-6}

A CHEAP SELECTIVE-ION ELECTRODE (SEN 1981, Vol. 30 No. 1)

Iain Townsend, Mitchell CAE

Summary

Selective-ion electrodes are widely used in industry and in research. However, they are unlikely to find their way into the high schools until some way can be found to decrease their price. This article describes a way to use a broken pH electrode as a selective-ion electrode, thus killing two birds with the one stone. A glass membrane electrode is such a fragile thing that most of us have had one on our hands at one time or another! However, the broken electrode and its attendant pH meter can now be used in a variety of analyses in the environment.

Introductory Theory

The selective-ion electrode which will be most familiar to the majority of readers will be the glass electrode used in pH measurements. The glass electrode is sensitive to the activity of H^+ in solutions and, in conjunction with the saturated calomel electrode, forms an electrochemical cell the output of which can be readily measured. The sensitivity of the glass electrode is due to the ability of the glass membrane to exchange H^+ ions for alkali metal ions in the glass. If this membrane is subsequently broken and removed the silver electrode is exposed directly to the solution. The electrode is coated with an adherent coat of silver chloride. Fricke and Kuntz (1977) state that such an electrode will be in solubility equilibrium with the chloride ion activity present in the solution. The voltage output of such a cell, measured using the mV function of the pH meter, will obey the equation: $E = 2.3 RT/nf \log A$

Where E is the potential, A is the ionic activity, n is the valency and R and F have their usual meanings. The electrical potential of the cell is the reduction potential of that activity of Ag^+ ion which is present in solution in equilibrium with the chloride ion and in the presence of $AgCl$ precipitate.

Figure 1. shows a plot of mV vs $-\log Cl^-$; Fricke and Kuntz claim that a double junction reference electrode is necessary for most ions analysed by this technique; however this was not done since the broken glass electrode used had its saturated calomel electrode as an integral part. Stopping the leakage of chloride ions into the solution being tested would have been impossible. In spite of this good results were obtained. A linear regression was carried out on the data, using a Hewlett-Packard HP97 calculator. Results showed that the data were highly linear ($r^2 = 1.00$). It is likely that for the concentrations employed and the level of accuracy, this refinement can be omitted. Furthermore, most readers would only be interested in selective ion

electrodes as teaching experiments where absolute accuracy may be desirable but not strictly necessary.

EXPERIMENTAL

The pH meter employed was a Pye Unicam Model 292 and the electrode was a Pye-Ingold Eo7 combined glass and reference electrode. The electrode had previously been dropped and so it was necessary to trim the jagged glass off, taking care not to disturb the Ag/AgCl electrode or the reference electrode. The electrode was stored in distilled water when not in use. It is probable that any meter/electrode combination could be used, provided the meter measures ± 700 mV, estimating the last place visually.

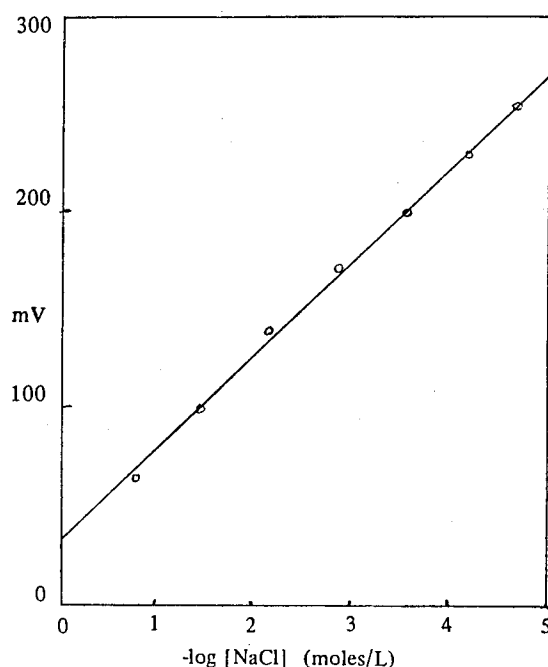


Figure 1: Plot of voltage output for different concentrations of sodium chloride in distilled water. The line of best fit was obtained from a linear regression as described in the text.

Calibration

The calibration curve shown in Figure 1 was obtained by preparing a standard NaCl solution (0.1737M) and then 1:5 serial dilutions. Set the meter to measure mV and follow the manufacturers' instructions as to calibration, etc. In my case, the meter was set at zero for distilled water. Solutions of NaCl prepared as above were then used, starting at the lowest concentration. A magnetic stirrer can be used, but is not necessary. Allow at least one minute for the reading to become steady.

It is necessary to recalibrate before each use. Discard the standards whenever the calibration is no longer a straight line. The lowest concentrations appear to be most affected either due to the effect already described by Fricke and Kuntz or else by contamination.

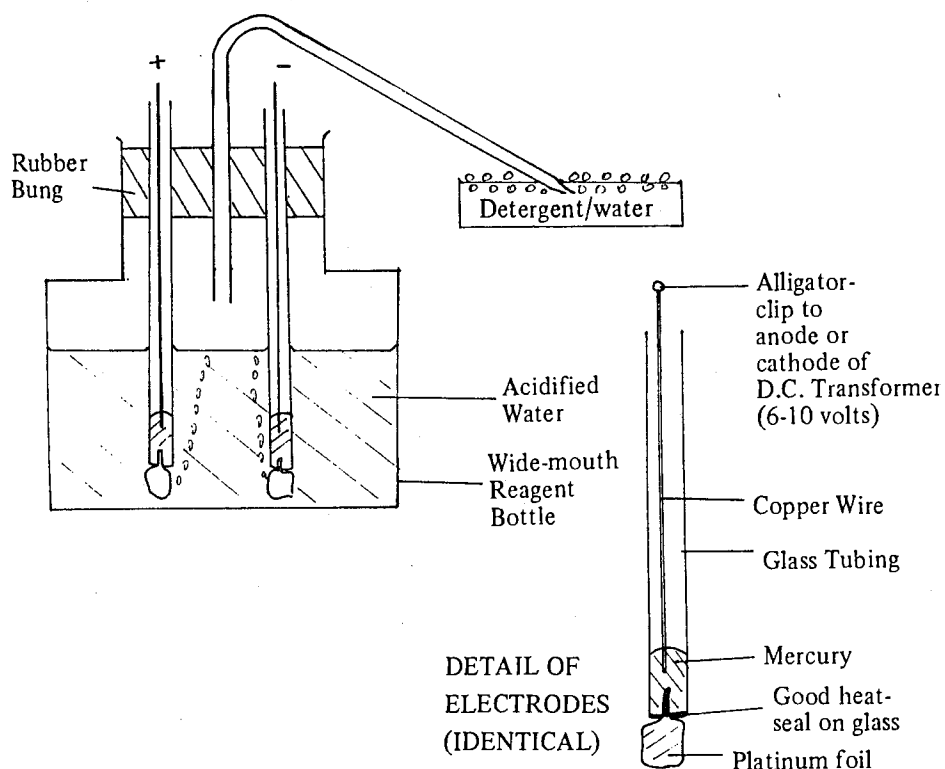
The electrode is now ready for use in analysing water samples for their chloride content. For chlorides, interferences from the other halides are the most troublesome, but in many natural waters the heavier halides at least should be present in insignificant concentrations. Solutions should not be strongly acidic or basic.

REFERENCE

1. Fricke, G.H. and Kuntz, M.J., *Journal of Chemical Education*, 54, 1977 517-520.

For many years now I have used the simple apparatus described below to demonstrate the energy potential of hydrogen gas.

The apparatus is basically similar to any 'electrolysis of water' apparatus. However, in this case, both gases produced (2 volumes hydrogen, 1 volume oxygen) are collected **together**, thus they are in the correct molar proportions for recombination to form water. Unlike the normal combustion of hydrogen in air (21% oxygen), this reaction results in the immediate release of **all** the energy available in hydrogen gas.



The hydrogen/oxygen gas mixture is bubbled into a petri dish of detergent and water. When a good collection of bubbles has been produced, **turn off the current and remove the apparatus to a safe distance**. A match is then applied to the bubbles and a safe, open explosion like a rifle shot is produced.

Students may be asked to trace the energy pathway (electrical energy - chemical potential energy - kinetic energy). They may discuss the

efficiency of the process (some energy lost as sound; also the apparatus becomes warm after a period).

The reaction can be related to the current discussion concerning hydrogen powered cars. Students can be asked the origin of the energy needed to produce the hydrogen and oxygen gases (the sun).

A recent television program, 'Hydrogen - the Forever Fuel', may be available on video as a follow-up teaching aid.

Note on Construction

The heat seal between the glass tubing and the platinum foil must be perfect. If it is not the mercury conductor will be rapidly lost.

Concepts: Uses

Motivation; formation of a gel; solubility of salts.

Materials

Calcium acetate - 34g/100mL; ethanol (or methylated spirits) - about 250 mL; 3 beakers.

Safety Notes

Care with ethanol

Preparation

- * Prepare a saturated solution of calcium acetate (34g/100mL). An appropriate volume would be 100mL. Place this in a 500mL beaker (or larger).
- * Place about 250mL of methylated spirits (or ethanol) in a beaker.

Procedure

- * Quickly pour the methylated spirits into the solution of calcium acetate.
- * Then attempt to pour the contents of this beaker into another beaker.

Observation

- * The calcium acetate should form a gel that will solidify.

Comments

- * The calcium acetate and ethanol form a gel (a liquid dispersed in a solid), demonstrating that the calcium acetate is not soluble in ethanol (though soluble in water).
- * The gel can be squeezed to remove most of the alcohol, placed on a heat resistant mat and lit (the alcohol will burn). This is sometimes called 'burning snow'.

ENERGY FROM CHEMICALS (SEN 1981, Vol. 30 No. 2)

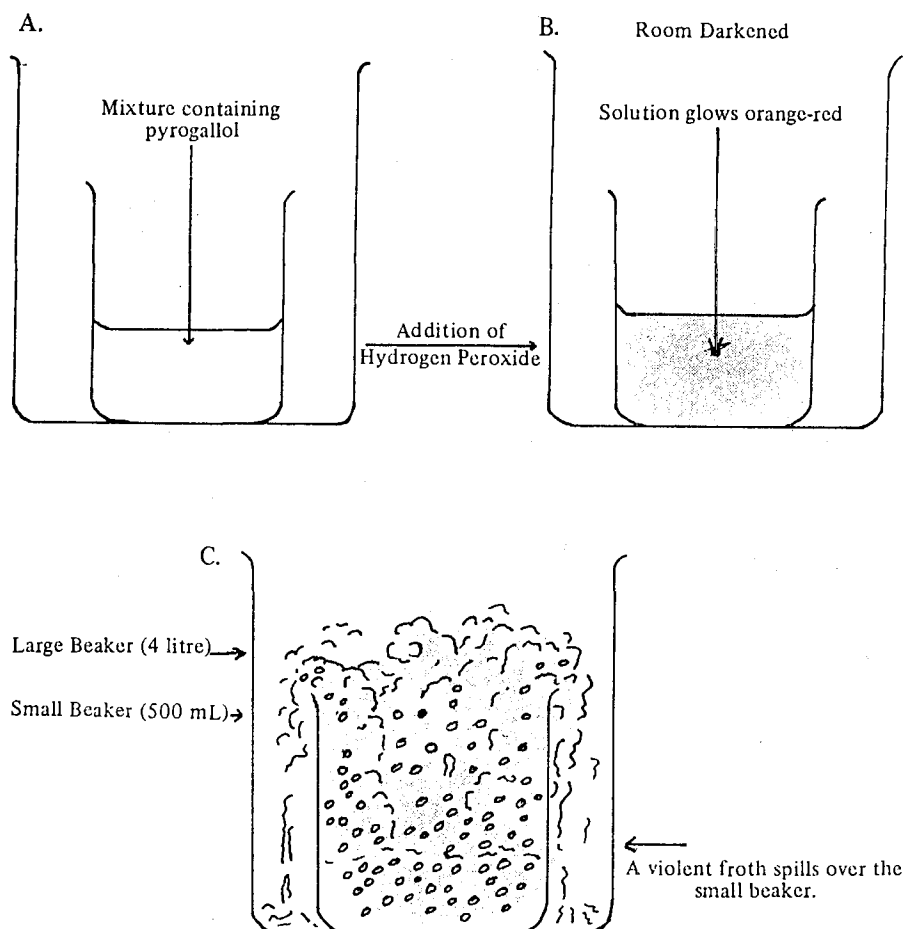
Tom Rozga, Sydney Technical HS

Introduction

A flame is a zone in which chemical reactions between gases is accompanied by the evolution of heat and light. A flame could be simply described as glowing gas. Solids emit flames if gases or vapours form on heating. Transparent gases such as nitrogen and oxygen do not glow when heated to a high temperature within tubes.

Flame is produced in chemical reactions liberating much energy and the emission of light is due to chemical reactions. **Chemiluminescence** may be regarded as a cold flame. The glow of phosphorus is a familiar example and if ether is dropped on a hot iron plate a greenish phosphorescent flame is seen.

The following reaction demonstrates chemiluminescence in solution. Light of the wavelength emitted accelerates the reaction which is thought to involve the oxidation of pyrogallol and the evolution of much heat.



Preparation of Solutions and Procedure

1. Add, in order, into a 500mL beaker: 10mL of 10% aqueous pyrogallol, 10mL of formaldehyde and 20mL of a saturated solution of potassium carbonate (21g in 20mL of water).
2. Place the beaker into a 4L beaker, darken the room and then add 30mL of 100 volume hydrogen peroxide. Stand well clear and observe the orange-red glow followed by a vigorous reaction which froths violently over the small beaker.

NOTE

Make sure you do not spill any of the final product on yourself or the furniture. It is corrosive. Have pupils stand well clear from the demonstration.

100V hydrogen peroxide is not on the Requisition. You will have to purchase it from a chemical supplier and preferably obtain it fresh as it decomposes with time and the effectiveness of the demonstration will dwindle.

I have performed this demonstration for junior and senior chemistry classes. It provides an exercise for accurate observation as well as to demonstrate energy conversions in a spectacular manner.

An addition to the demonstration is to add 100mL of 0.1% luminol in 2M sodium hydroxide after the addition of 100mL of formaldehyde in Step 1. This causes the bubbling froth produced towards the end of the demonstration to glow a lilac colour and lighten a dark room. Luminol is expensive and may be obtained from Scientific and Research Equipment, Thornleigh. Approximate price \$25 for 5g, but this amount will last out many demonstrations.

Reference

General and Inorganic Chemistry, Partington J.R., Macmillan, London, Fourth Edition, 1966.

THE FOUNTAIN EXPERIMENT (SEN 1981, Vol. 30 No. 2)

R.G.Paton, Diploma in Education student, Sydney Teachers' College

Concepts

Air pressure, solubility of gases, ammonia gas as a base.

Apparatus

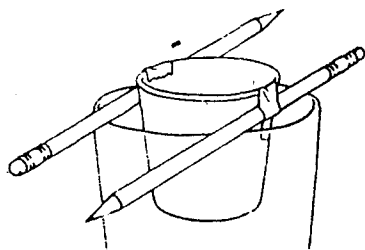


Figure 1a.

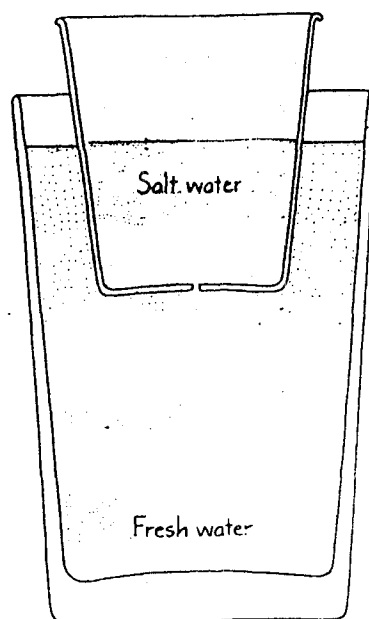


Figure 1b. *The basic salt oscillator*

Generation of Dry Ammonia Gas

Drop concentrated ammonia solution onto about 20g NaOH pellets in a generator as shown and collect by downward displacement of air.

Generation of HCl Gas

Add 10mL concentrated H_2SO_4 to 20g NaCl solid in a generator as shown and collect by upward displacement of air.

Safety Precautions

Generation of gases should be carried out in a fume cupboard.

Procedure

Start the fountain by squirting water from the eye dropper into the florence flask to dissolve some of the gas and so lower the pressure inside the flask. Solution is forced into the flask from the beaker.

Comments

Both ammonia and HCl gases are extremely water soluble, hence the rapid drop in pressure inside the flask.

Alternatives and Additions

1. A simple demonstration of air pressure/contraction of gases on cooling can be obtained by heating a small amount of water in a florence flask and while still hot, placing a rubber bung containing a long glass tube in the neck of the flask. The flask is inverted over a beaker of water as in the diagram above. Cooling of the gas inside the flask causes a 'fountain' similar to that above.
2. An inverted florence flask containing dry ammonia gas over a beaker of strong hydrochloric acid solution instead of water can be used to demonstrate the reaction of NH_3 as a base and so initiate a discussion of 'What is a base?'

Reference

Joseph et al., *A Sourcebook For the Physical Sciences*, Harcourt, N.Y., (1961), pp160-161.

CATALYSIS, A TRANSITION METAL AND OXIDATION-REDUCTION

(SEN 1982, Vol. 31 No. 1)

Dennis Mather, Leichhardt HS

The following reaction is useful because it is directly relevant to three sections of the chemistry syllabus, but it could also be used for a junior chemistry demonstration as well.

Some catalysts provide a surface upon which a reaction takes place, others take part in the reaction forming an intermediate which subsequently decomposes to yield the original material. The evidence for such a process is normally difficult to provide without sophisticated equipment. An exception is the oxidation of potassium sodium tartrate (Rochelle salt) by hydrogen peroxide using cobalt (II) chloride.

Procedure

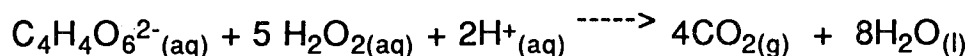
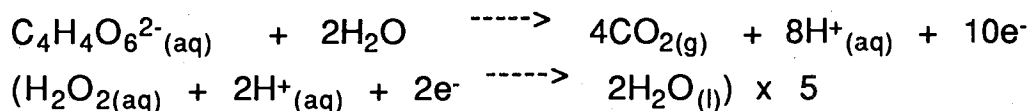
Weigh out 1g of potassium sodium tartrate ($\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$) and place it in a beaker. Dissolve it in 25mL of water with gentle heating. When the solution reaches 60-70°C remove the bunsen, place the beaker on a piece of white paper on the bench and add 2mL (approximately) of 27% (100 volume) hydrogen peroxide (handle carefully, hydrogen peroxide will produce mild burns on the skin). Where more dilute hydrogen peroxide solutions are available the volume will need to be increased. At this stage little reaction will be observed.

Add 1mL (approximately) of cobalt chloride catalyst solution (10g per 100mL), stir and carefully observe:

1. the onset of the reaction
2. a change in colour as the catalyst forms and intermediate compound
3. a return to the original colour of the catalyst when the reaction is complete.

Tartrate is the conjugate base of a dicarboxylic acid - see Figure 1.

It is oxidised in the same way as oxalic acid:



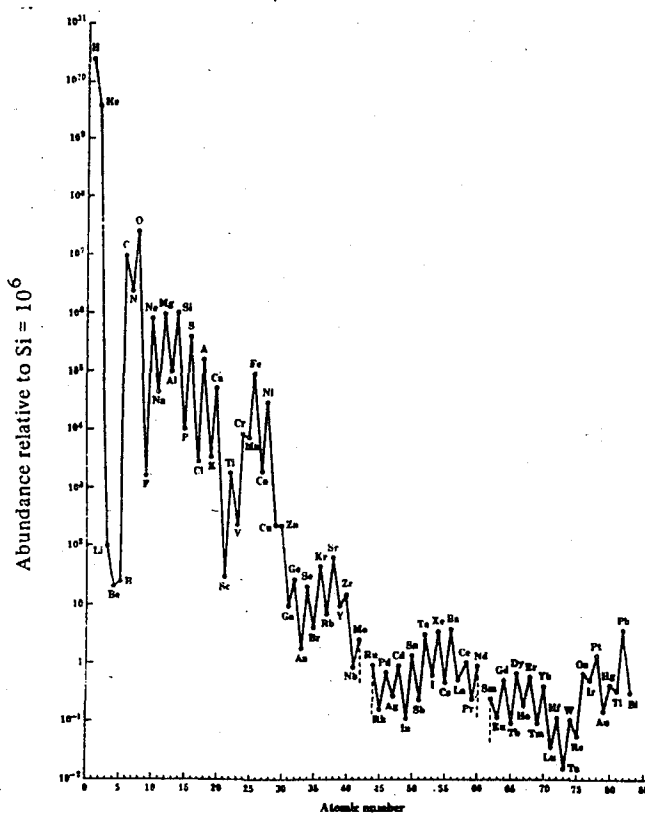


Figure 1. Comparative abundance of the elements in the universe relative to silicon = 10^6

From Distribution of Elements in Our Planet, Ahrens, McGraw-Hill, 1965

There is an initiation time which will depend on the concentration of cobalt (II) in the reaction mixture (see below), as well as ambient temperature, after which carbon dioxide is evolved as a gas. Simultaneously the solution changes colour from the pale pink of the aqueous cobalt (II) ion to a bright green. This colour probably indicates the presence of cobalt (III). When the effervescence ceases the green colour simultaneously reverts to the previous pink.

The reaction is quite sensitive to the concentration of cobalt (II) ions in a most unexpected way. If too much is added the reaction is not catalysed as well as it is with smaller concentrations. In addition the green colour of the reaction intermediate is not as apparent because it is mixed with the pink of the unchanged aqueous cobalt (II) ions.

The carbon dioxide evolved can be collected in a gas jar over lime water. The changes in the colour of the solution (pink to green to pink) demonstrate in a most explicit way the use of a catalyst in a reaction followed by its return at the end of the reaction.

COMPARATIVE ABUNDANCES OF THE ELEMENTS (SEN 1982, Vol. 31 No. 1)

Dennis Mather, Leichhardt HS

It has been my experience that the new 2 Unit Chemistry syllabus has asked for information which was not required by the previous syllabus. Some of this information has been difficult to obtain while other data were found in references not usually used by chemistry teachers. For instance, in core unit (a) the last suggested experience states:

Preparation of a chart showing the comparative abundances of the elements in the universe, on earth, in animal and plant bodies, and as used in industry

I am still searching for the comparative abundances as used in industry!

The following table represents the information relevant to this suggested experience that I have gathered myself, from other teachers as well as from references.

Element	Crust	Element	Crust
Li	20	Ag	0.07
Be	2.8	Cd	0.2
B	10	In	0.1
F	625	Sn	2
Na	2.4%	Sb	0.2
Mg	1.95%	Te	
Al	8.2%	I	0.5
Si	28.2%	Cs	3
P	1,050	Ba	425
S	260	La	30
Cl	130	Ce	60
K	2.1%	Pr	8.2
Ca	4.2%	Nd	28
Sc	22	Sm	6
Ti	0.57%	Eu	1.2
V	135	Gd	5.4
Cr	100	Tb	0.9
Mn	950	Dy	3
Fe	5.6%	Ho	1.2
Co	25	Er	2.8
Ni	75	Tm	0.5
Cu	55	Yb	3
Zn	70	Lu	0.5
Ga	15	Hf	3
Ge	1.5	Ta	2
As	1.8	W	1.5
Se	0.05	Re	
Br	2.5	Os	
Rb	90	Ir	
Sr	375	Pt	
Y	33	Au	0.004
Zr	165	Hg	0.08
Nb	20	Tl	0.45
Mo	1.5	Pb	12.5
Ru		Bi	0.17
Rh		Th	9.6
Pd		U	2.7

Table 1. Estimated abundances of elements in the Earth's crust. Unless otherwise stated the values are in parts per million (1 ppm = 0.0001%)

From Distribution of the Elements in Our Planet, Ahrens, McGraw-Hill, 1965

Mineral		Annual output (million tonnes)
iron ore	Fe	675
manganese	Mn	18.36
aluminium	Al	7.8
copper	Cu	8.4
chromate	Cr	4.8
asbestos	—	3.5
lead	Pb	2.9
nickel	Ni	.5
tin	Sn	.2
molybdenum	Mo	.1

Table 2. The ten most commercially important minerals by value of annual output (source not known)

Element	Symbol	Approximate % (by weight) of man	Approximate % (by weight) of maize	Approximate % (by weight) of yeast
oxygen	O	65	75	72
carbon	C	18	13	14
hydrogen	H	10	10	10
nitrogen	N	3.3	0.45	2.4
calcium	Ca	1.5	0.07	0.01
phosphorous	P	1.0	0.06	0.5
potassium	K	0.35	0.28	0.6
sulfur	S	0.25	0.05	0.005
sodium	Na	0.24	trace	0.05
chlorine	Cl	0.19	0.04	—
magnesium	Mg	0.05	0.06	0.05
iron	Fe	0.005	0.03	0.005
manganese	Mn	0.003	0.01	—
silicon	Si	trace	0.46	—

Table 3 — Elements most common in animal; plant — and micro organisms (source not known)

COLOURFUL CHEMICAL DEMONSTRATIONS (SEN 1982, Vol. 31 No. 2)
Dennis Mather, Leichhardt HS

1. Rainbow

Place 50mL of saturated boric acid solution (Note: boric acid dissolves slowly) in a 250mL beaker and stir with a magnetic stirrer. Add several drops of universal indicator so that the solution becomes bright red. Slowly add 0.5 mol L⁻¹ sodium hydroxide solution. The sequence of colours produced is red, orange, yellow, green, blue, indigo and violet. The sodium hydroxide solution must be added dropwise initially but once the solution becomes green it can be added more quickly. At the end, addition of acid drives the system

back to any of the above colours. This is a straight titration of saturated boric acid solution with aqueous sodium hydroxide, the universal indicator responding to the pH changes. Boric acid acts as a monobasic acid. For the addition of 50mL of sodium hydroxide, the pH change is approximately from 4 to 10. Students could be given the pH ranges for the various colours of universal indicator and asked to plot a pH/volume curve which should be that for a weak acid/strong base titration. The pH vs volume curve is shown in Figure 1.

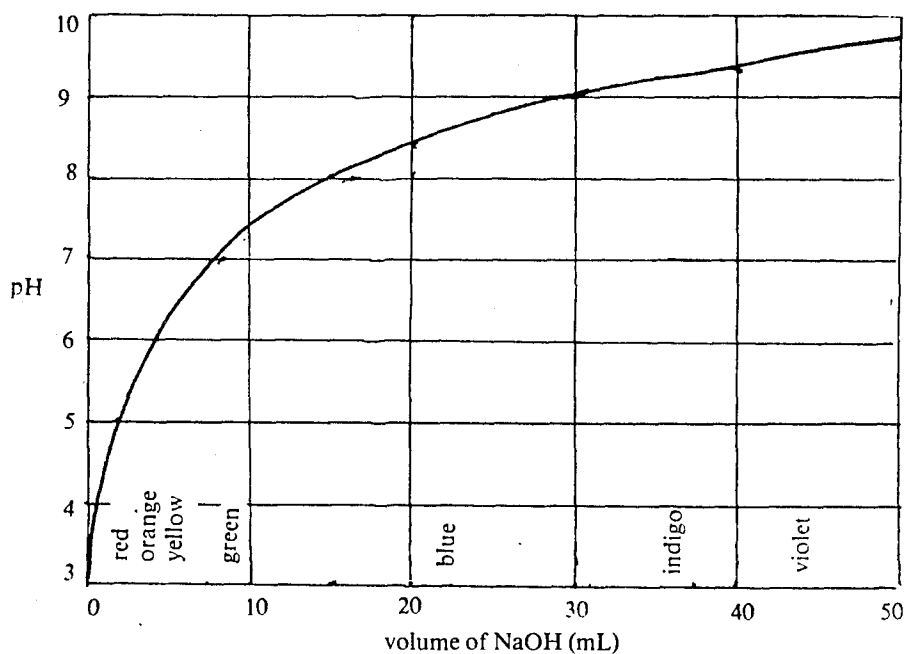


Figure 1.

2. Colour Changing Bottles

- (i) Dissolve 11g potassium hydroxide in 500mL of water in a florence flask and then add 18g of glucose. Add sufficient crystals of methylene blue to give a deep colour;
or, 300mL water + 10g dextrose + 10g sodium hydroxide (the important thing is to have a reducing sugar in an alkaline solution).
- (ii) Repeat using indigo carmine instead of methylene blue.
- (iii) After dissolving the potassium hydroxide add a very few crystals of methylene blue and leave to stand until the solution turns purple before adding the glucose.

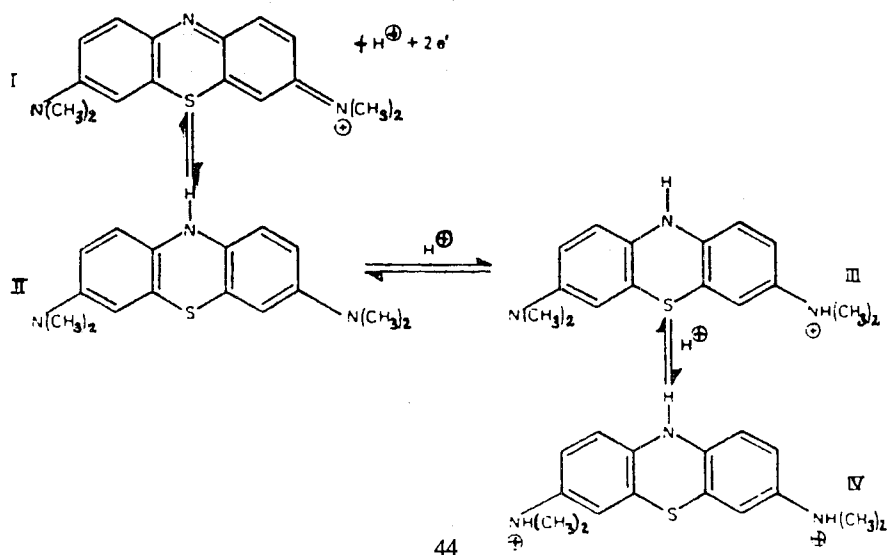
Stopper the bottles and allow to stand. Gently swirl and then vigorously shake the flasks.

- (i) The solution goes from colourless to blue.
- (ii) The colour changes from yellow, through red to green. An appropriate patten about traffic lights may be used.
- (iii) The solution goes from colourless to purple.

The original colours return on standing. When the colours fade, they can be rejuvenated by removing the stopper to let in air.

This demonstration is a very useful deductive exercise in kinetics, as shown in a stimulating discussion of this demonstration; the explanation given here takes a somewhat different view of the process. The reaction involves aerial oxidation of the glucose which, on standing, reverts to the reduced form, the colour changes being due to the redox indicators. The potential (relative to the saturated calomel electrode) varies from about 150mV on vigorous shaking to about 500mV on standing. Other redox indicators with appropriate potentials could be used. In the case of the indigo carmine, careful observation after vigorous shaking shows that the red appears initially at the bottom of the flask while for methylene blue a thin layer is visible in the meniscus, both observations providing evidence for aerial oxidation.

The redox chemistry of methylene blue has been extensively studied; it is complicated by the fact that methylene blue is sensitive to the pH. The currently accepted reaction scheme is as follows: at the ph of this demonstration the reactions involve species I and II.



3. Oxidation-Reduction Reactions Involving Transition Metal Ions

(i) Reduction of Vanadate with Zinc

Prepare a solution of vanadate ions by dissolving 10g of ammonia vanadate in 500mL 0.5 mol L⁻¹ sulfuric acid. Add granulated zinc to some of this solution.

The zinc will appear to be reacting with the acid in the usual way, but after about five minutes the colour of the vanadate solution will change. If it has not, add some extra acid, say 1mL 8 mol L⁻¹.

Thus the vanadate ion is reduced by zinc (or atomic hydrogen) through recognisable stages from V (V) to V(II), if you are patient enough (possibly up to 30 minutes).

The species obtained are listed with their colours:

VO ₃ ⁻ (aq)	orange	V ³⁺ (aq)	green
VO ²⁺ (aq)	blue	V ²⁺ (aq)	violet

The divalent ion is quite unstable and is easily oxidised to V³⁺(aq) by atmospheric oxygen. It will only be formed while there is plenty of zinc and acid in the solution. Also, fill the test tube so as to minimise the surface area/volume.

(ii) **Reduction of the Chromate Ion with Zinc**

This is a similar reaction to the one above. Prepare a solution of potassium chromate by dissolving 10g of potassium chromate in 500mL of 0.5 mol.L⁻¹ sulfuric acid. Add granulated zinc to some of this solution.

This reaction will produce Cr³⁺_(aq) with no trouble at all, in about 10 minutes. If a test tube full of the solution is used with an excess of zinc, the patient observer will obtain a glimpse of the Cr²⁺_(aq) ion.

The colours of the various species of chromium formed are given below:

CrO₄²⁻_(aq) yellow

Cr³⁺_(aq) green

Cr²⁺_(aq) blue

4. Cobalt (II) as an Indicator of Humidity

Cobalt (II) is well known as an indicator for water, in self-indicating silica gel (for desiccating) and in cobalt chloride paper.

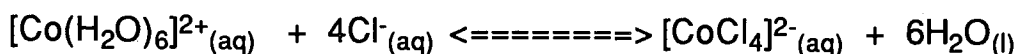
Cobalt chloride paper can be made by preparing a solution of 10g of cobalt chloride in 50mL of water. Soak filter paper in the solution and dry it in an oven until it turns blue. Store in a desiccator over a desiccant.

Similar colour changes can be produced in solution. Aqueous Co (II) is pale pink, but if crystals of cobalt (II) chloride are dissolved in ethanol the solution is an intense blue colour.

This can be used as an example of an equilibrium reaction since water added to the ethanol solution will turn it pink. It is, however, more difficult to turn the aqueous solution blue by adding ethanol; best conditions occur with very concentrated solutions in small quantities.

In water the cobalt exists as [Co(H₂O)₆]²⁺, an octahedral coordination compound. Each of the water molecules has formed a coordinate bond, through the oxygen, with the cobalt.

Cobalt (II) is capable of forming tetrahedral complexes under certain conditions. [CoCl₄]²⁻ is an intensely blue species and probably other tetrahedral complexes, such as [Co(H₂O)Cl₃]⁻. A simplified reaction can be written:

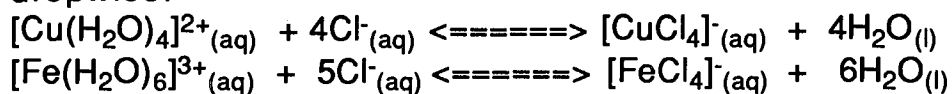


This reaction can also be investigated in aqueous solution, using concentrated hydrochloric acid as the source of chloride ions.

5. Colourful Equilibria with Copper (II) and Iron (III) Solutions

Prepare concentrated solutions of copper nitrate and iron (III) chloride. Since copper nitrate is deliquescent, the solution which often forms on the top of these crystals in reagent bottles is ideal for these purposes.

Add concentrated hydrochloric acid dropwise to 1mL of each of these solutions in separate test tubes. The copper (II) will change from blue to green/yellow; the iron (III) will change to a much paler yellow. These changes can be reversed by adding water dropwise.



1. Introduction

Towards the end of the eighteenth century chemists displayed a particular interest in the reactions between different gases. In 1781, Henry Cavendish found that whenever he exploded hydrogen with oxygen, a given volume of hydrogen would react with half its own volume of oxygen. In 1805, Joseph Louis Gay-Lussac repeated this experiment and confirmed that two volumes of hydrogen always reacted with one volume of oxygen, provided that the volumes of hydrogen and oxygen were measured under the same conditions of temperature and pressure.

Gay-Lussac was so intrigued by the simplicity of the 2:1 ratio that he went on to examine the combining volumes of other pairs of gases and found that:

1 volume hydrogen + 1 volume chlorine \rightarrow 2 volumes hydrogen chloride
 1 volume nitrogen + 2 volumes oxygen \rightarrow 2 volumes nitrogen(IV) oxide

In 1808, Gay-Lussac published his Law of Combining Gas Volumes. When gases react, the volumes of the reacting gases and the volumes of any gaseous products are in the ratio of small whole numbers, provided the volumes are measured at the same temperature and pressure.

Chemists then began to look for an interpretation of Gay-Lussac's Law in terms of Dalton's Atomic Theory of Matter published in 1803. They realised that 100mL of nitrogen just reacted with 200mL of oxygen and the number of nitrogen and oxygen molecules must be simply related, otherwise some molecules of oxygen and nitrogen would be left over after the reaction.

In 1811, the Italian scientist Amadeo Avogadro suggested an important hypothesis which later became known as Avogadro's theory: equal volumes of all gases at the same temperature and pressure contain equal numbers of particles. This suggestion by Avogadro explains beautifully the experimental results which lead to Gay-Lussac's Law.

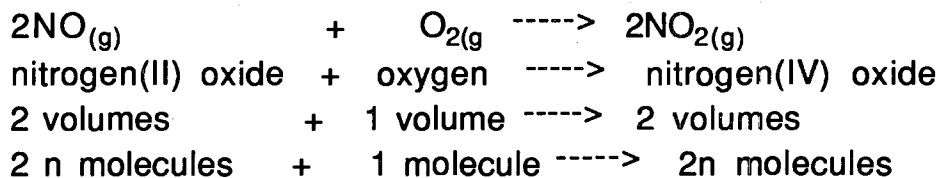
For example, in the reaction of nitrogen and oxygen if we assume one volume of nitrogen contains n molecules, then by Avogadro's theory two volumes of oxygen contain $2n$ molecules and two volumes of nitrogen dioxide contain $2n$ molecules.

nitrogen	+	oxygen	\rightarrow	nitrogen(IV) oxide
1 volume	+	1 volume	\rightarrow	2 volumes
n molecules	+	n molecules	\rightarrow	$2n$ molecules

In all reactions involving gases the number of moles of gas is proportional to its volume at constant temperature and pressure. There is no reason to believe that the total volume of reactants should equal the total volume of products because there is no rule concerning the conservation of the number of molecules in a chemical reaction.

Suitable reactions to demonstrate these theories in the school are difficult to find but the one described below provides for us the basis for a spectacular example.

Nitrogen(II) oxide (nitric oxide, NO) reacts with oxygen producing nitrogen(IV) oxide (nitrogen dioxide, NO₂) as the only product.



Nitrogen(II) oxide is a colourless gas, a neutral oxide and sparingly soluble in water. Nitrogen(IV) oxide is a red-brown gas, soluble in water forming an acidic solution.

2. Procedure

Two demonstrations can be used to show the reaction.

Demonstration 1

- Take two 500mL round bottom flasks. On each determine the level of 50 per cent volume. The usual 500mL round bottom flask occupies a volume of about 830mL from the base of an inserted cork. Therefore the 50 per cent volume mark will read 415mL.
- Set up the apparatus shown in Figure 1 and generate nitric oxide by slowly dropping concentrated sulfuric acid onto solid sodium nitrate covered with about three times its weight of water. This produces very pure nitric oxide. The reaction can be summarised by the following equation:



When water is left to the level of the base of the longer glass tubing in flask 1, clamp the rubber tubing at positions A and E. Disconnect the rubber tubing from the gas generator at A. This preparation should be performed in a fume cupboard.

Figure 1. Generation of Nitric Oxide

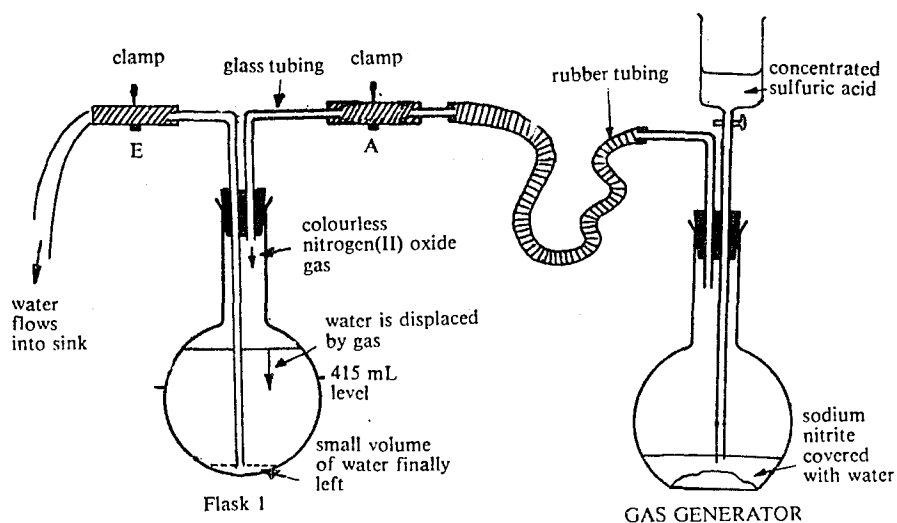
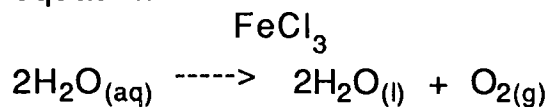


Figure 1. Generation of Nitric Oxide

- (c) Set up the apparatus shown in Figure 2 and generate oxygen gas by dropping 10 vol. hydrogen peroxide onto 20mL of a hot aqueous solution of iron(III) oxide until the water level is at the base of the longer glass tube. Ferric chloride acts as a catalyst in the decomposition of hydrogen peroxide according to the following equation:



Disconnect the rubber tubing at C, clamp the rubber tubing at position B and insert the glass tubing into the rubber tubing at position A on the flask containing the nitrogen(II) oxide.

- Note:**
- Generate oxygen gas for a minute or so in order to remove the original air in the gas generator.
 - Generate all gases with care. Add concentrated sulfuric acid and hydrogen peroxide slowly so a steady slow rate of gas generation is maintained.

Figure 2. Generation of Oxygen Gas

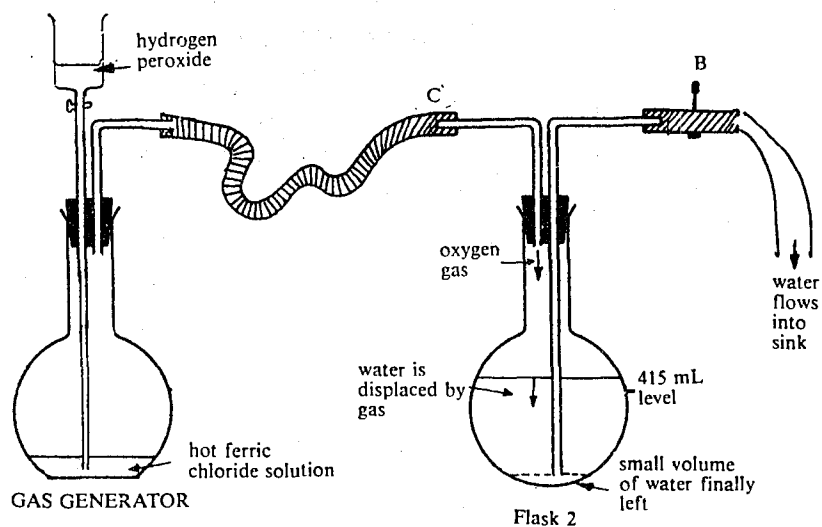


Figure 2. Generation of oxygen gas

- (d) Fill a large beaker with two litres of water, coloured green with universal indicator and connect by means of glass tubing to position B as shown in Figure 3. Both clamps are closed.

Figure 3. Reaction of Nitrogen(II) Oxide with Oxygen

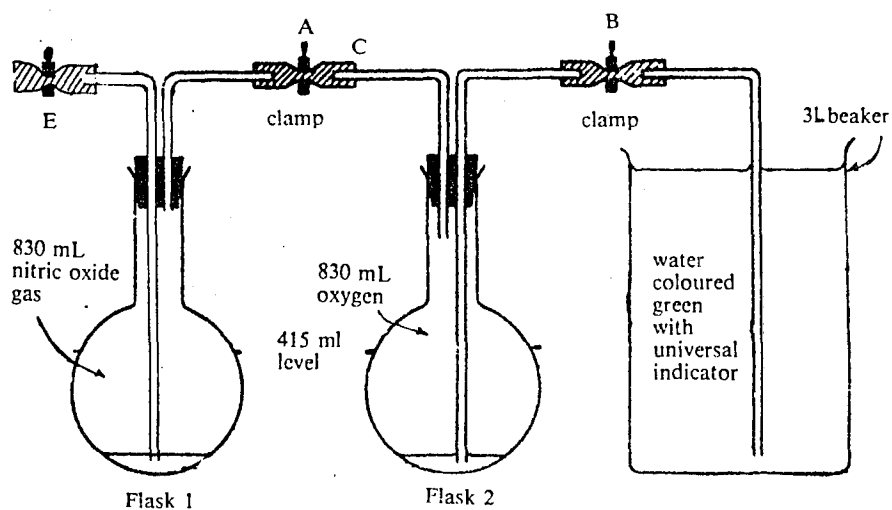


Figure 3. Reaction of nitrogen(II) oxide with oxygen.

- (e) The apparatus shown in Figure 3 is now ready. Open clamps A and B. After a minute or so the faint red-brown colour of nitrogen(IV) oxide appears at the opening to flask 1. This creates a small decrease in gas volume with a corresponding reduction in pressure. Oxygen begins to diffuse into flask 1 and water moves onto flask 2 to take its place. By this time the reaction between nitrogen(II) oxide and oxygen is quite rapid, further reducing the pressure. Water from flask 2 begins to move into flask 1, dissolving all the nitrogen(IV) oxide that forms. The universal indicator turns yellow in flask 1, due to the solution of nitrogen(IV) oxide, for example:

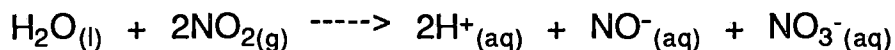
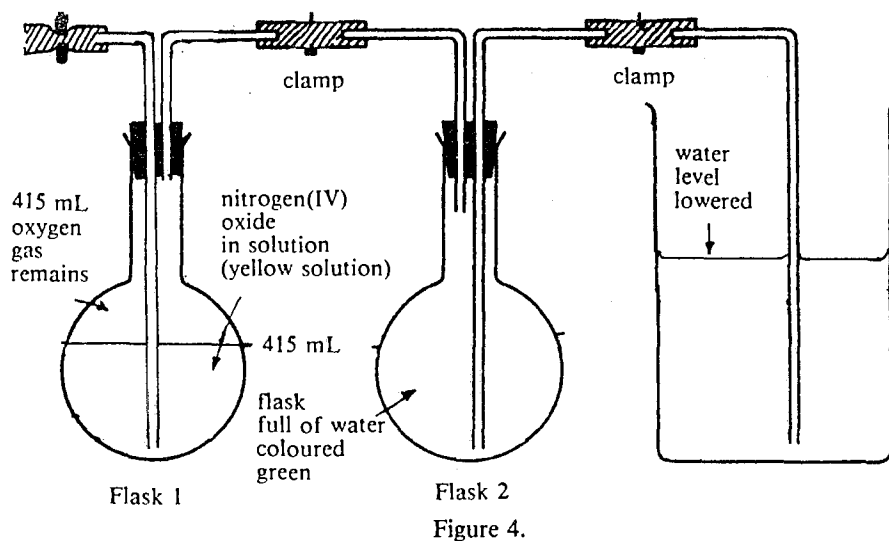


Figure 4 shows the state of the demonstration after complete reaction. The gas remaining in flask 1 can be tested. If nitrogen(II) oxide remains, combination with oxygen in the air on removing the cork forms brown nitrogen(IV) oxide. This does not occur. Oxygen is the remaining gas.

Figure 4.

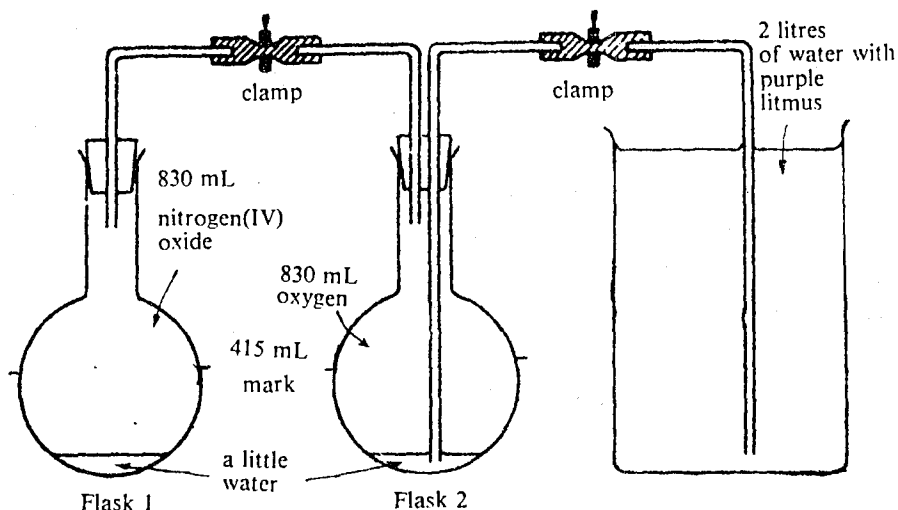


The demonstration clearly confirms that 830mL of nitrogen(II) oxide reacts with only 415mL of oxygen. It provides an ideal opportunity for careful observation and a worksheet could be designed to incorporate the chemistry involved.

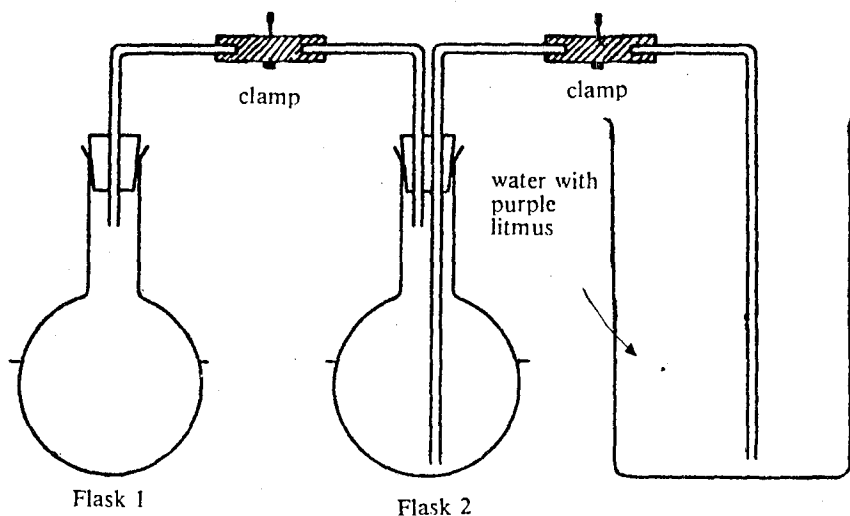
Volume Relationships Between Reacting Gases

Nitrogen(II) oxide (NO) reacts with oxygen gas producing nitrogen(IV) oxide as the only product.

- (a) The apparatus below illustrates the initial stage of the demonstration. Both clamps are closed.

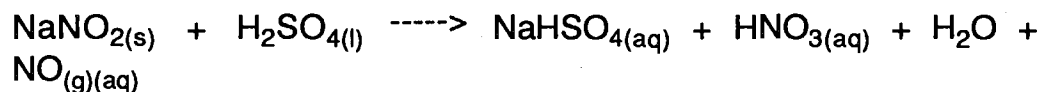


- (b) Both clamps are opened together. On the diagram below draw in any new water levels and record all your observations.



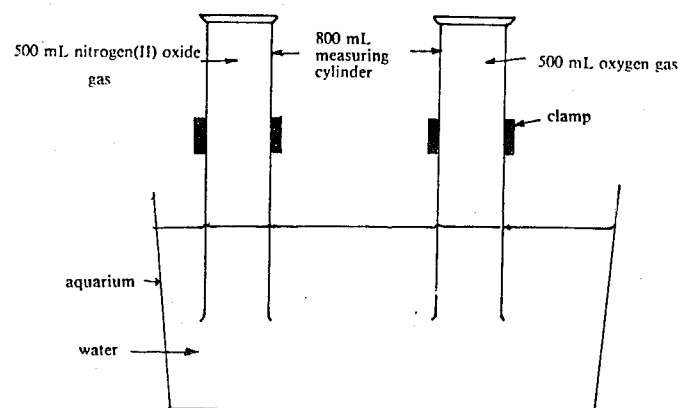
WORKSHEET

1. Make an assumption about the nature of the remaining gas in flask 1. 2. Suggest a method to identify the gas.
3. The method in 2 was performed. Record the result and the nature of the remaining gas.
4. State the volume ratios that nitrogen(II) oxide and oxygen combine in.
5. What conclusion can you draw about the volume ratios of reacting gases from this demonstration.
6. Write a balanced equation for the reaction in which nitrogen(II) oxide combines with oxygen to form nitrogen(IV) oxide.
7. Water moves into the flasks from the beaker as a result of a reduction in pressure. Give a reason for this reduction in pressure.
8. Explain the change in colour of the universal indicator solution. Supplement your explanation with an equation.
9. The oxygen required for the demonstration was prepared by the decomposition of hydrogen peroxide using manganese as a catalyst. Write an equation for this reaction.
10. The nitrogen(II) oxide was prepared by the reaction of sodium nitrate and concentrated sulfuric acid shown by the reaction below. Balance the equation.

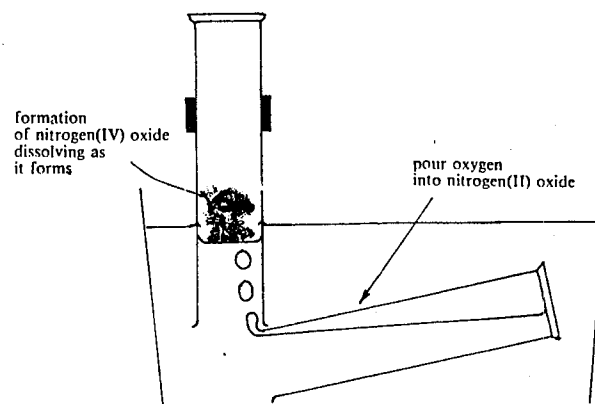


Demonstration 2

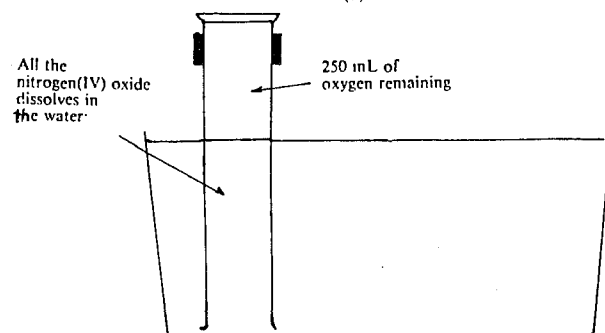
- (a) Set up the apparatus shown in Figure 5a. Into one of the measuring cylinders collect 500mL of nitrogen(II) oxide and in the other 500mL of oxygen. Adjust the cylinders so that the pressure of both gases is constant.
- (b) Pour all the oxygen gas slowly into the nitric oxide. The red-brown nitrogen(IV) oxide that forms dissolves, leaving 250mL of oxygen gas.



(a)



(b)



(c)

Figure 5.

Have you used colourful as well as smelly demonstrations to illustrate what you thought was the kinetic theory? The intent was to show that molecules in water or in air are in constant motion. If you had enough time in the period you would put dye into a beaker of water and have students watch the colour diffuse. On rushed days, however, you would put an open dish of ammonia water on the front desk and wait for the grimaces at the rear of the room.

Unfortunately neither demonstration illustrates diffusion, a process of *random* spreading in which particles of a liquid, gas, or solid collide spontaneously. In the case of ammonia in air, breezes and convection produce air currents that mechanically and *non-randomly* mix the air and ammonia. Similarly, ordered currents due to convection, density gradients and unsettled liquid are responsible for mixing the dye in the water. These demonstrations no more show diffusion than scrambling an egg illustrates 'diffusion' of the yolk.

Even bromine evaporating in a measuring cylinder does not really illustrate pure diffusion. The bromine vapour moves up the measuring cylinder, in part because it is mechanically pushed up by the almost thousandfold increase in volume that occurs in the change from a liquid to a vapour. As more liquid evaporates more gas is pushed up and more air is forced out of the measuring cylinder.

An experiment to show the rate of ammonia diffusion through air can be performed using a 50x1cm glass tube. The tube is supported horizontally and plugged with cotton. A few drops of concentrated ammonia solution are placed on the inside end of the cotton plug and a few drops of concentrated hydrochloric acid on the other. (The cotton plugs release the excess pressures and therefore eliminate mechanical forces on the gas.) In about 20 minutes a white disc of ammonium chloride forms where the two gases meet. As the experiment demonstrates, without much mechanical mixing the diffusion of ammonia gas is quite slow.

What about the dye demonstration in water? It takes several minutes of standing still before the large scale mechanical movements of the liquid cease; even then invisible fluid movements are caused by convection. To let students see these, tell them to do the following.

Fill a 250mL beaker with 4-5cm of soapy water made by adding several drops of dishwashing detergent to about 1L of hot water. Shake the beaker until there is a layer of foam on top, approximately 2cm deep,

made of small bubbles. Cover the beaker and let it stand for at least five minutes.

When all evidence of movement stops, carefully place two or three drops of food colouring on the top centre of the foam. In one to three minutes, the dye solution filters down between the bubbles and enters the liquid. (If not, add another drop or two of dye)

The foam hinders evaporation and cooling of the liquid and arranges the descending dye into an array of streams that slowly drain down. As long as the beaker is not moved, a complex and persistent pattern of colour slowly and mysteriously develops throughout the liquid, outlining the otherwise invisible convection cells that constantly transport fluid in an uncovered glass of water.

The shape of the pattern is dependent upon variables like the depth of the water, the shape of the glass, the temperature difference between air and liquid and even the proximity of the glass to a light or window. (The radiant energy from a closely held flashlight provides enough heat to visibly perturb the dye pattern.) The pattern stands out best when viewed against a white background such as a piece of paper.

A GAS SAMPLING DEVICE (SEN 1982, Vol. 31 No. 4)

The Science Teacher: March 1982

Inflate a balloon with gas. Use only the volume of gas required by your class. The advantage of using a balloon is that it can be expanded to contain 'large' volumes of a variety of gases. Insert a 5cm length of plastic tubing (11-20mm diameter) into the neck of the balloon. Insert a rubber septum into the open end of the plastic tubing. Use a simple plastic syringe to remove samples of the gas for testing.

A GAS DISCHARGE TUBE (SEN 1984, Vol. 33 No. 1)

Warwick Shephard, Macquarie BHS

A gas discharge tube can be easily assembled using government issue equipment. See Figure 1 for set up. It is important to note that wires A and B must be separated by at least 3 to 5cm and that wire A must be at least 7cm above the base of the bell jar apparatus (to avoid arcing).

This apparatus can illustrate such things as cathode and anode glow, negative glow and positive striations. It can also be used to demonstrate the relationship between gas discharges and changing pressures.

Variation: Wires A and B can be replaced by various shaped copper pieces to produce a larger glow area.

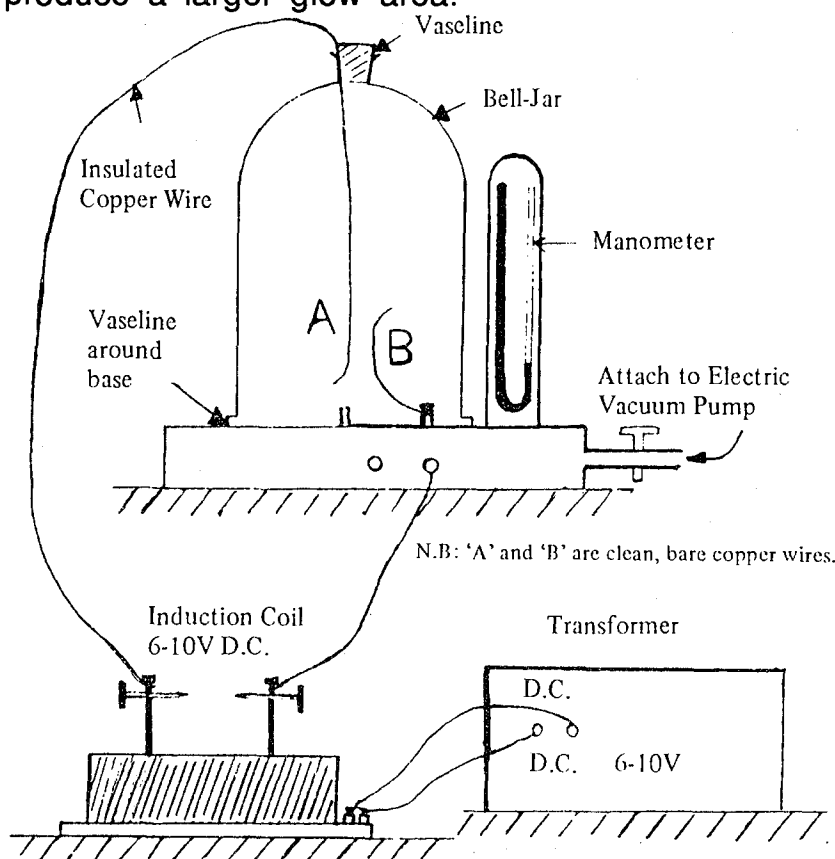


Fig. 1. Gas Discharge Tube Reprinted from Labscene, Vol. 7, No. 3 1983

SOAP MAKING - AN ALTERNATIVE RECIPE THAT WORKS (SEN 1983, Vol. 32 No. 3)

Joy Reid, Peakhurst HS

Discussion

The origin of soap is a mystery, but one suggestion is that Roman women discovered it by accident about 3000 years ago. They washed their clothes where rain water flowed from the hills into the River Tiber and over altars where animals had been slaughtered. The fat from the sacrifice and the ashes from the fire are said to have combined as the first crude soap.

Basic Recipe

- 1/2 cup of cold water
- 2 tablespoons caustic soda
- 1 cup of melted tallow.

(Tallow can be made by melting lumps of animal fat (dripping) over a low heat in a heavy saucepan. Strain to remove streaks of blood and bits of meat, etc., if necessary. Place in warmed screw top jars and store in the refrigerator.)

Method

Place the water in a heat resistant bowl, add caustic soda and stir immediately. When the caustic soda solution has cooled to lukewarm, add lukewarm melted tallow slowly, stirring continually. Beat gently with an egg whisk for about 4 minutes. (At this stage other fats and oils may be added to vary the soap, perfume and colour may also be added, whisking well) Pour the mixture into clean, *pliable* plastic moulds. (Margarine containers, pre-pack dessert containers, plastic trays for holding yoghurt, ice cube trays, etc.) and leave to set for about 24 hours. Gently ease the soaps out of their moulds and transfer onto a piece of kitchen paper to mature in a dry, well-ventilated place for two weeks.

Variations

1. Some of the tallow in the above recipe may be replaced by other oils, e.g. coconut oil, olive oil, almond oil, castor oil, safflower oil, baby oil. The tallow seems to be what makes the soap hard, so the more oil in the mixture the softer the soap becomes. General rule of thumb; have at least 1/2 tallow 1/2 oil.
2. Perfumes; use essential oils, e.g. rose oil, lavender oil, pine oil, strangeflower oil, cinnamon oil or sandalwood oil (about 2 teaspoons). Also, rose water, witch hazel (1/4 cup, but reduce the amount of water in the recipe).
3. The soap can be coloured by adding food colourings.
4. Experiment with additions like infusions of ground herbs, oatmeal, lanolin, cucumber, avocado or strawberry pulp. (These are all reputed to be beauty treatments!)

1. Amoeboid Motions

These are best performed on an overhead projector.

- * Fill a petri dish with 4-6 molar ammonia solution and into the centre place a drop of oleic acid. The oleic acid will disperse rapidly into the ammonia solution, showing rapid amoeboid movements as it does so. More drops can be added until neutralisation occurs. The product is ammonium oleate.
- * A second, more spectacular version uses mercury, nitric acid and potassium dichromate. Into a dilute solution of nitric acid add a drop of mercury about half the size of a 1 cent coin. Place a rice grain sized crystal of potassium dichromate into the petri dish. As the dichromate dissolves a yellow colour is seen to diffuse through the nitric acid. When the yellow boundary encounters the drop of mercury, rapid amoeboid motions result. These will continue for some time. Mention must be made that the movements observed are much more rapid than those an amoeba is capable of.

2. Nylon

Prepare the following solutions:

- a) 1.5mL of adipyl chloride in 50mL of cyclohexane.
- b) 2.2g of 1, 6- diamiohexane and 4g sodium carbonate in 50mL of water.

Slowly add the adipyl chloride solution to the water solution.

Polymerisation will occur at the interface. Pull out the interfacial film with forceps and run it over a set of rollers. Once sufficient nylon has been formed, the system will be self sustaining.

The collected nylon should be washed in ethanol, then air dried at 110°C.

3. Squeezing a Glass Bottle

Many of us experience discrepant events but hardly ever try to figure out, in a logical manner, why and how they occur. Here is an activity to stimulate interest in learning science through an activity which seems contrary to our first line of reasoning.

Materials: water, 10 cent coin, empty drink bottle.

Procedure: Place the coin over the mouth of the bottle. Drop a little water around the edge to seal it. Grasp the bottle with both hands and squeeze. The coin will begin to dance up and down. As the air inside the bottle expands from being warmed by your hands, the coin lifted to relieve the pressure. The squeezing per se has no effect upon the glass other than to raise the temperature.

DEMONSTRATION DIAPHRAGM CELL FOR THE ELECTROLYTIC PRODUCTION OF SODIUM HYDROXIDE (SEN 1984, Vol. 33 No. 1)

This model cell is easily constructed from common materials and it shows in a convincing manner that hydroxyl ions are produced at the cathode and chlorine at the anode.

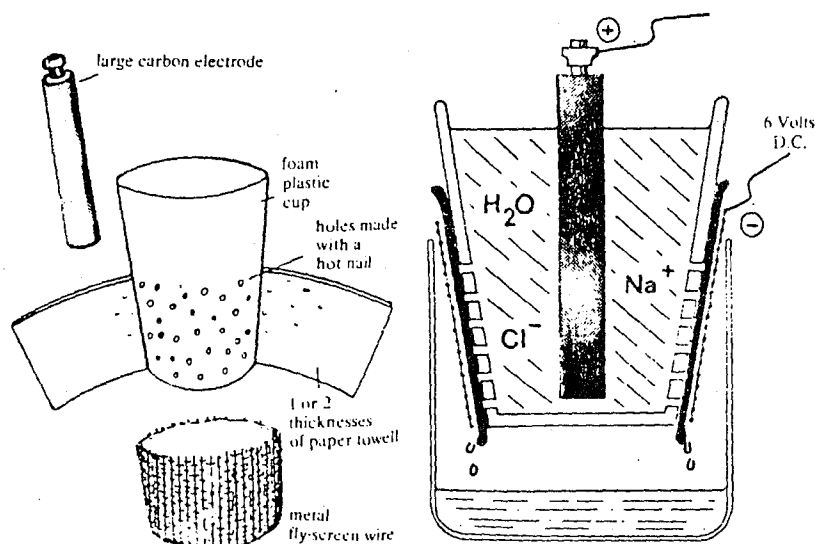
A foam plastic cup provides a porous container when holes, 1 or 2mm in diameter are made in the lower half of the cup and that part of the cup is wrapped in one or two thicknesses of paper towelling or filter paper. Metal gauze fly-wire provides a wrap around mesh cathode and the whole apparatus sits easily in a glass beaker. The carbon anode may be made from one or more rods taken from used dry cells, preferably large ones. The salt solution should be concentrated.

The production of hydroxyl ions at the cathode can be shown strikingly by adding phenolphthalein indicator to the salt solution or, alternatively, to the beaker which collects the solution which 'weeps' through the porous diaphragm.

Anode Reaction: $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$

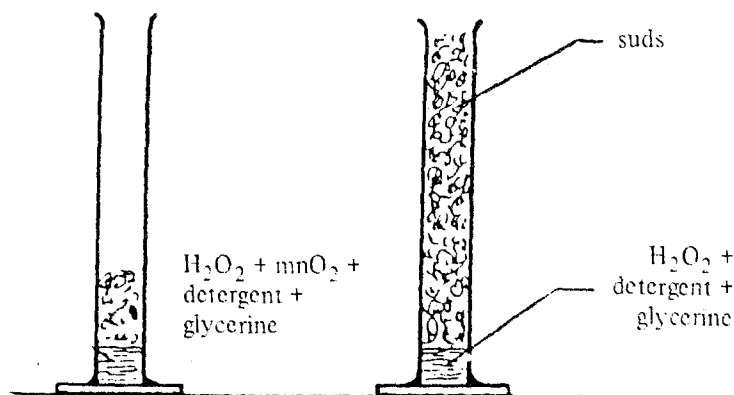
Cathode Reaction: $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{OH}^- + \text{H}_2$

The 'secret' of this cell's practical operation appears to be in equating the rates of electrolysis with the rate of solution seeping through the permeable diaphragm. Naturally there is usually an appreciable quantity of the impurity of the sodium chloride in the product.



Materials

1. Two tall cylinders or narrow jars.
2. Liquid detergent, glycerine, hydrogen peroxide (H_2O_2), manganese dioxide (MnO_2)
3. Two long stirrers (long straws will do).



Procedure

1. Place about 10mL of hydrogen peroxide and 5mL of detergent and about 5mL of glycerine in each cylinder.
2. Add a pinch of MnO_2 to one of the cylinders and stir the mixture in both cylinders with the long stirrers.
3. Observe the difference in height of the produced suds in the two tall cylinders.

Questions

1. In which of the two cylinders did the suds rise higher?
2. What causes the suds to go up higher in one of the cylinders?
3. What do we need to make soap bubbles?
4. What function does the peroxide have in this reaction?
5. What do the MnO_2 and the glycerine do?
6. Would the suds rise just as high without the stirring?
7. What other substances might be used in place of MnO_2 ?

Explanation

The detergent functions like the soap when blowing soap bubbles. By adding some glycerine to the detergent, the surface tension of the liquid is increased and the bubbles will stay longer before collapsing. In order to get suds in a soap solution when blowing bubbles, we need to blow through a straw into the detergent mixture. In this case we do not need to blow. Where are we getting the gas to blow the bubbles from? The gas is supplied by the hydrogen peroxide, which decomposes into water and oxygen. The MnO_2 acts as a catalyst for this oxygen producing reaction. It does not partake in the reaction, but only facilitates it. This means that the properties of MnO_2 before and after the reaction are unchanged. Dust and dirt particles or ashes could replace the MnO_2 .

MAKING A BREATHALYSER (SEN 1984, Vol. 33 No. 2)

Robyn Smith and Fred Love, Parramatta HS

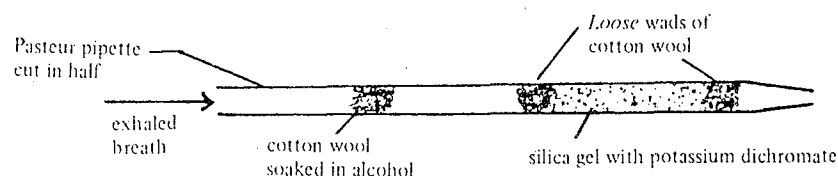
A breathalyser test kit can be made simply and quickly by students. The method below works well and can be used as a chemical experiment or to stimulate discussion on the social problems of alcohol and drink-driving.

Materials

- * Silica gel, chromatographic grade (as supplied)
- * Potassium dichromate, as saturated solution in 3mol.L⁻¹ sulfuric acid
- * 3-4mm tubing, e.g. plastic pasteur pipette
- * cotton wool

Procedure

1. (Optional). Heat the silica gel **gently** to drive off absorbed water. Cool to room temperature.
2. Cover a small quantity of silica gel (1-2g) with the dichromate solution. Pour off excess solution.
3. Spread the silica gel onto blotting paper or filter paper and move around with a spatula until dry.
4. Pack the tubing with the silica gel as shown below.



5. In the absence of any inebriated teachers (or students) (!) the action can be demonstrated by using a small wad of cotton wool soaked in ethanol. Breathe out through the tube for 10-15 seconds. The colour change in the 'crystals' takes 1-2 minutes to develop fully.

A. The Solubility of Potassium Chlorate

Introduction

Potassium chlorate is a slightly soluble salt. By measuring its solubility over a range of temperatures, the solubility product constant, (K_{sp}), for potassium chlorate can be calculated over a range of temperatures.

Materials

Electronic balance	potassium chlorate
5 test tubes	test tube rack
bunsen burner	tripod
gauze	500mL beaker
thermometer	10mL measuring cylinder
spirit based marking pen.	

Procedure

1. Prepare a beaker of boiling water.
2. Label 5 test tubes 1 to 5 and add 1.00g, 1.25g, 1.50g, 1.75g and 2.00g respectively of potassium chlorate to the test tubes. (These weights are not critical; if you find you have 1.02g, say, in test tube 1, leave it, but record **that** weight in your book.)
3. Add 10.00mL of water to each test tube and place them in the boiling water bath. Swirl gently until all the solid dissolves.
4. Remove test tube 1 and place a thermometer in it. Observe the test tube for the first sign of crystallisation and **note** the temperature.
5. Repeat with test tubes 2 to 5.

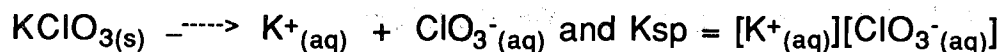
Record your results as indicated below.

Test tube	Weight of $KClO_3$	Temperature of Saturated Solution
1	1.00g	
2	1.25g	
3	1.50g	
4	1.75g	
5	2.00g	

Graph the weight of $KClO_3$ versus the temperature of the saturated solution.

Calculations

The equation for the dissolution of KClO_3 is:



In this experiment the solubility of KClO_3 in moles per litre (M) is

$$[\text{K}^+_{(aq)}] = [\text{ClO}_3^-_{(aq)}]$$

1. Calculate the solubility of KClO_3 in moles per litre for each of your five results.
2. Using these results calculate the value of K_{sp} for each temperature where crystallisation first occurred.

Question

Is the dissolving of KClO_3 an exothermic or an endothermic process? Explain, using Le Chatelier's Principle.

B. The Solubility Product of Silver Chromate

This experiment enables the range of values for the K_{sp} of silver chromate to be determined.

Materials

$1 \times 10^{-2} \text{ mol L}^{-1} \text{ AgNO}_3$ (0.425g/250 mL)

$1 \times 10^{-4} \text{ mol L}^{-1} \text{ K}_2\text{CrO}_4$ (0.486g/250mL then a 1 in 100 dilution)

6x150mL beakers, 3 measuring cylinders, 2 gradual pipettes.

Procedure

Label 6 beakers 1 to 6, then add H_2O , $1 \times 10^{-2} \text{ mol L}^{-1} \text{ AgNO}_3$ and $1 \times 10^{-4} \text{ mol L}^{-1} \text{ K}_2\text{CrO}_4$ to each as indicated in the table below

	Beaker Number					
	1	2	3	4	5	6
H_2O	40mL	60mL	70mL	80mL	85mL	90mL
$1 \times 10^{-2} \text{ mol L}^{-1} \text{ Ag}^+$	40mL	20mL	10mL	10mL	10mL	5mL
$1 \times 10^{-4} \text{ mol L}^{-1} \text{ CrO}_4^{2-}$	20mL	20mL	20mL	10mL	5mL	5mL

Where a precipitate occurs (cloudiness) the ion product $> K_{sp}$ and where no precipitate occurs the ion product $< K_{sp}$. Hence the range of K_{sp} values can be determined.

Typically beakers 1, 2 and 3 are cloudy and beakers 4, 5 and 6 are clear. This indicates a K_{sp} value of about 1×10^{-11} to 2×10^{-11} .

C. Precipitation, a Case of Equilibrium

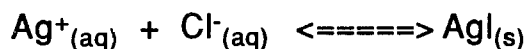
A student demonstration

Materials

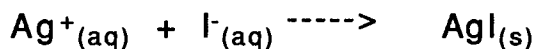
0.1 mol L⁻¹ NaCl, 0.1 mol L⁻¹ AgNO₃, 0.1 mol L⁻¹ KI, 1 mol L⁻¹ KI, 2 test tubes, stirring rod.

Procedure

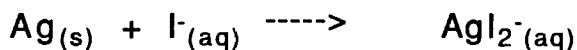
1. Add 2mL of 0.1 mol L⁻¹ NaCl to 2mL 0.1 mol L⁻¹ AgNO₃ to produce a white precipitate of AgCl.



2. Then add 2mL of 0.1 mol L⁻¹ KI while stirring. Note that the white colour of AgCl disappears and the yellow colour of AgI forms.



3. Then add 1mol L⁻¹ KI with stirring; note that the AgI dissolves.



Questions

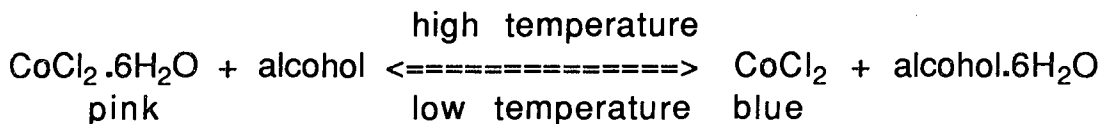
1. Why does the AgCl disappear?
2. Which is the more insoluble salt, AgCl or AgI?
3. Explain the observations in terms of Le Chatelier's Principle.

SOLAR ENERGY STORAGE: A DEMONSTRATION (SEN 1984, Vol. 33 No. 3)

H.S. Kimmel and R.S. Tompkins; Journal of Chem. Ed. Vol. 56, No. 9, SCP 1979.

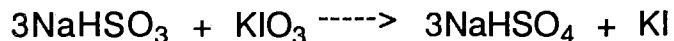
The concept of storing solar energy using phase change materials is receiving considerable attention at the present time. The inclusion of a simple demonstration experiment to illustrate this idea in general or physical chemistry provides an excellent example of the application of thermochemical principles. Several phase change materials are being considered, such as sodium sulfate decahydrate (Glauber's salts), where the stored energy is represented by the heat of hydration.

A laboratory experiment to determine the heat of hydration of a salt hydrate has been suggested. However, for the purposes of a lecture demonstration this experiment is unsuitable due to the time available and also the effect is not particularly visual. A more convenient demonstration experiment which is effective in showing the use of a phase transition for heat storage uses the reaction between cobalt chloride and alcohol.

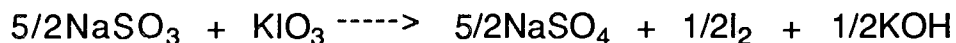


The demonstration is performed as follows. Dissolve about 1g of cobalt chloride hexahydrate, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ in 10mL of isopropanol so as to obtain a deep blue coloured solution. Water should then be added dropwise until a distinct pink colour appears. The water molecules preferentially solvate the cobalt ion forming the pink salt hydrate. The solution is then placed in a test tube or flask and heated in a beaker of hot water (solar energy). Almost immediately the pink colour is replaced by a blue solution as the anhydrous cobalt chloride has now formed. The pink colour will appear again as soon as the solution is immersed in cold water (cold night). This process can be repeated indefinitely.

The reactions discussed here are based on the famous clock reaction, which uses KIO_3 and NaHSO_3 . If sufficient NaHSO_3 is present the reaction will proceed as follows:



There will be no change in appearance. When little NaHSO_3 is present the reaction proceeds thus:

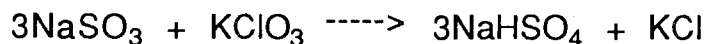


In the above reactions, suitable concentrations of the solutions are 0.05M KIO_3 and 0.125M NaHSO_3 . These two solutions will be referred to as A and B respectively. In the following reactions, these are diluted by about half. If A and B are equal in volume, the mole ratio will be 2.5:1; the subsequent reaction will be the clock reaction and I_2 will become visible in about one minute.

If the volume of the NaHSO_3 solution is 1.2 times that of the KIO_3 solution, the mole ratio becomes 3:1, and the first reaction above will result. In practice, good reliability is achieved by using a volume of NaSO_3 solution more than 1.3 times the volume of the KIO_3 solution.

Note: the concentrations should be those stated above unless otherwise specified.

In the following reaction, KClO_3 may be used instead of KIO_3 . In this case, the reaction proceeds as follows:



There will be no change in the appearance of the solution. A suitable concentration of KClO_3 is 0.4M. This will be referred to as solution C.

TRICK 1

Method

Dilute 30mL of A with 110mL of water and add 6mL of 0.1N solution of HgCl_2 . Then add 45mL of B and mix continuously using a magnetic stirrer. The solution will first appear colourless and transparent, but as I^- is produced through reaction of A and B, gradually Hgl_2 suspension

will appear as an orange suspension. As I^- increases further, the HgI_2 suspension will then change to the complex ion HgI_4^{2-} and the solution will become colourless and transparent as before. Note: when too much $HgCl_2$ is added the suspension will not disappear completely.

Caution is advised in the use of $HgCl_2$ because of its toxicity.

Alternate Method

To 30mL of A, 100mL of C and 7.5mL of a 0.1N solution of $HgCl_2$, add 45mL of B and mix continuously using a magnetic stirrer. The solution, which is colourless and transparent at first, will gradually become a muddy orange. After some time, it will suddenly turn a dark brown. If a suitable quantity of starch is added beforehand, it will turn a deep purplish blue. If the amount of Hg^{2+} is less, the colour of the I_2 will appear after the suspension disappears.

TRICK 2

Method

Dilute 30mL of A with 30mL of water and add 90mL of a 0.1N solution of $Pb(NO_3)_2$. Then add 45mL of B. A dense white suspension will form. Mix continuously using a magnetic stirrer. Since I^- is produced by reaction of A and B, the superfluous Pb^{2+} reacts with I^- and becomes PbI_2 and the suspension will turn yellow. As mixing is continued, SO_4^{2-} is yielded and PbI_2 will change to $PbSO_4$, which is a less soluble substance than PbI_2 , so that the suspension will turn white again.

Note: when there is too little Pb^{2+} , in spite of the presence of I^- , PbI_2 will not be formed and the suspension will not turn yellow. On the other hand, if there is too much Pb^{2+} , in spite of the presence of SO_4^{2-} all the PbI_2 will not turn into $PbSO_4$ and the yellow colour will not disappear completely.

TRICK 3

Method

Mix 30mL of B (1M), 45mL of a 2N solution of KI and 75mL of C. The resulting solution will be an almost colourless (slightly yellowish) solution. Let the solution stand for a while and it will gradually change from yellow to bright yellow. The colour will subsequently fade away. If the solution is allowed to stand for a while longer, it will begin to turn yellow again and finally will become re-orange. The last change will take place more rapidly if the solution is heated. The colour changes occur when the mole ratio of H_2SO_3 to I^- is in the range of 1:4.

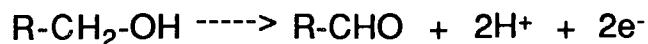
AN OXIDATION REACTION: 1-PROPANOL TO PROPANOL

(SEN 1985, Vol. 34 No. 2)

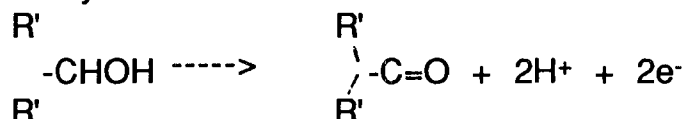
Chris Wiecek, Warilla HS

Introduction

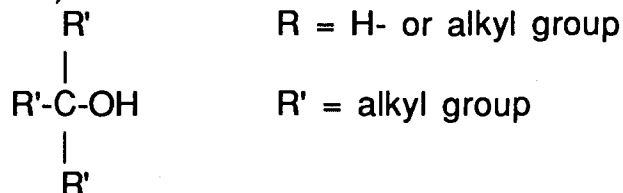
Alcohols differ in their behaviour with oxidising agents. Primary alcohols are oxidised first to an aldehyde and then to a carboxylic acid.



Secondary alcohols are oxidised to ketones.



Tertiary alcohols are not oxidised with oxidising agents other than oxygen. (They will burn.)



In the case of primary alcohols the oxidation of the aldehyde formed is easier than its formation, hence it is difficult to isolate the intermediate aldehyde. However, aldehydes usually have much lower boiling points than either alcohols or carboxylic acids, so that it is sometimes possible to distil out the aldehyde from the reaction mixture as it is formed.

For example: propanol has B.P. = 97°C
propanal has B.P. = 49°C
propanoic acid has B.P. = 141°C

If the reaction mixture for the oxidation of propanol is maintained at 85-90°C only propanal will distil out.

Typical oxidising agents suitable for oxidation of alcohols are acidified solutions of permanganate or dichromate salts of sodium or potassium.

Equipment and Chemicals

1-propanol (n-propanol, propyl alcohol), conc. sulfuric acid, sodium dichromate,

0.1 mol L⁻¹ silver nitrate, 0.1 mol L⁻¹ potassium dichromate,

0.1 mol L⁻¹ aqueous ammonium solution.

Quickfit

50mL pear shaped flask, stillhead, condenser, tap funnel, thermometer, teflon adaptor, receiver adaptor, Claisen stillhead, fractionating column, boiling chips, clean test tubes, beakers, bunsen, clamps, retort stands, measuring cylinders.

Procedure

Dissolve 10.5g of sodium dichromate in 20mL water. Cautiously add 8mL conc. sulfuric acid with stirring. Place 8mL propanol in a pear shaped flask and assemble the equipment as set out below.

Run water through the condenser. If a Claisen stillhead and fractionating column are available they attach to the top of the pear shaped flask, with the stillhead and condenser attached to the top of the fractionating column.

Add boiling chips to the propanol and place the acidified sodium dichromate solution in the tap funnel. Using a bunsen burner bring the propanol to boiling, then add the acidified sodium dichromate **dropwise** over about ten minutes. It should not be necessary to heat the reaction any further. The propanol will distil out of the reaction mixture. Note the boiling points above.

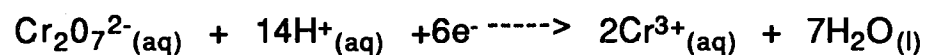
Collect the propanol in a test tube. A good yield is 2-3mL.

Reactions of Propanol

1. Prepare Tollens reagent by adding 0.1mol L⁻¹ aqueous ammonia solution to 0.5mL 0.1mol L⁻¹ AgNO₃ dropwise until the precipitate just dissolves.
Add 3 drops of propanol, warm (in a warm water bath). Observe.
Clean this test tube immediately, as explosive substances may form on standing.
A silver nitrate mirror will form on the glass, as the propanol is oxidised.
2. Add a drop of dilute sulfuric acid to 0.5mL 0.1mol L⁻¹ potassium dichromate. Add 3 drops of propanol and warm.
The colour changes to green as the propanol is oxidised.
3. Add 3 drops of propanol to 0.5mL Benedicts or Fehlings solution.
The colour changes to the red colour of Cu₂O as the propanol is oxidised.
4. Repeat 1, 2 and 3 with propanol. What differences are there?

Questions

1. Write the half-equation for the formation of propanol.
2. By combining it with the half-equation for the reduction of dichromate:



write the overall equation for the reaction.

3. 8mL of propanol was used in this experiment but only about 2-3mL of propanol was isolated. Suggest what may have happened to the 'missing' 5-6mL.

THE PREPARATION OF BENZOIC ACID FROM BENZYL CHLORIDE

(SEN 1986, Vol. 35 No. 1)

Chris Wiecek, Warilla HS

Benzoic acid may be prepared from benzyl chloride under alkaline oxidation conditions. A substitution reaction occurs initially to form benzyl alcohol which oxidises to benzaldehyde and then to benzoic acid.

N.B. Care must be taken to avoid any contact with the skin with benzyl chloride and the refluxing must be done in a flask less than half full to avoid 'bumping'.

Benzyl chloride is available in many schools and hence this reaction provides a useful oxidation reaction for a chemistry class to observe carboxylic acid being produced. I do the experiment as a demonstration with class participation.

Materials

500mL round bottomed flask, condenser, benzyl chloride, potassium permanganate, sodium carbonate decahydrate, sodium sulfate solution (20% w/v), conc. hydrochloric acid.

Procedure

Place sodium carbonate decahydrate (10.8g), potassium permanganate (9g) and 200mL of water in a 500mL round bottomed flask. Add boiling chips and benzyl chloride (4.5mL). Reflux for 90 minutes, allow to cool, add conc. HCl (40mL) and then sodium sulfate while shaking until the manganese dioxide is dissolved and only a white precipitate of benzoic acid remains. Filter the benzoic acid off, wash with cold water and recrystallise from boiling water. The melting point is 120-122°C.

**HYDROLYSIS OF THE ESTER METHYL SALICYLATE (SEN 1985,
Vol. 35 No. 1)
Chris Wiecek, Warilla HS**

The hydrolysis of esters is part of the Carbon Chemistry elective in 2U Chemistry. The hydrolysis of methyl salicylate is a simple procedure where the products are dramatically distinct from the reactants. Methyl salicylate (present on most school shelves) is highly aromatic. Most students immediately recognise the odour. The products are methanol and salicylic acid (a white solid).

Materials

methyl salicylate, sodium hydroxide, conc. hydrochloric acid, boiling chips, 100mL round bottomed flask, condenser, stillhead, thermometer, teflon adaptor, fractionating column, acidified potassium dichromate solution.

Procedure

Weigh 20g of methyl salicylate into 100mL round bottomed flask. Add a solution of sodium hydroxide (6g in 40mL water) and boiling chips. Reflux until a clear solution results. Allow to cool and attach a fractionating column, stillhead, condenser and thermometer. Heat slowly and collect the fraction boiling below 70°C (B.P. of methanol is 65°C).

Test the product with an acidified solution of potassium dichromate. A small sample can also be tested for flammability. Finally, dismantle the glassware and acidify the solution in the round bottomed flask with conc. HCl (10mL). Allow to cool and filter off the salicylic acid. Wash with a little cold water and recrystallise from boiling water. Filter and dry the product and measure its melting point (158°C).

Dissolve a sample in water and test with blue litmus.

USING A DISSECTING MICROSCOPE IN TEACHING INTRODUCTORY CHEMISTRY (SEN 1986, Vol. 35 No. 3)

Robert Winokur, University of Nevada; Manus Monroe, Indian Valley Colleges.

In an effort to have high school students develop observational skills and acquire an excitement about chemistry, stereoscopic dissecting microscopes (magnification 7 to 40X) have been used to observe the physical characteristics and chemical reactions of several substances, a few of which are described in this article. The reactions must be viewed using a bright source of direct incident (not transmitted) light. Both lights and microscopes can often be borrowed from a biology department. Depression slides are useful but not essential. Safety glasses are recommended, especially when working with acids.

Reactions with Copper Sulfate

Students are instructed to adjust the magnification of their microscope to between 20 and 30X and place a drop or two of distilled water onto the depression of a glass slide. A few grains of freshly prepared anhydrous copper sulfate are placed, using a spatula, extremely close to, but not on the water drop. Students first observe that what appears as white powder to the naked eye is actually granular. Within 2-5 minutes, some of the granules gradually change to light blue crystals. After viewing the colour change, students are then instructed to push several granules into the water, using either a needle or a small glass rod and to observe the individual hydrated crystals. Students then add additional anhydrous copper sulfate to the drop of water and stir and the rate at which the crystals dissolve is noted. The relationship between the rate of dissolution and the concentration of a solution is discussed, as well as the concept of (equilibrium) vapour pressure of water and the use of copper(II) sulfate as an indicator in dessicants.

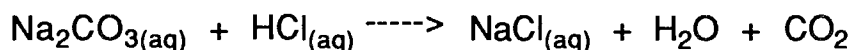
With the magnification set at 10 or 15X, a few particles of magnesium powder are finally added to the solution. The production of copper metal on the surface of the magnesium particles is then observed. The details and the possible mechanism for this redox reaction are discussed, as well as the physical contact required between the solid magnesium particles and the aqueous copper(II) ions in the solution. If the students see the production of gas bubbles (hydrogen) on the surface of the metallic particles, due to a redox reaction between magnesium and hydrogen ions, it would indicate that the distilled water was slightly acidic.

Reaction Between Magnesium Powder and 1 mol L⁻¹ HCl

Another procedure that is especially effective for this type of magnified observation is the reaction between magnesium powder and 1 mol L⁻¹ HCl. The individual particles are animated by the production of hydrogen gas bubbles on their surfaces and make a compelling spectacle when viewed under magnification. Students are instructed to adjust the magnification to 10 or 15X, to place a few drops of 1 mol L⁻¹ HCl into the depression in the slide and to add a few particles of magnesium. A magnification of 20 to 30X will allow a close-up view of the animated particles and gas production. At this point, if appropriate, discuss the concept of redox reactions between hydrogen ions and some elemental metals.

Reactions Between Sodium Carbonate and HCl

Students are instructed to adjust the magnification to between 10 and 30X. Next, they place approximately 1mL of 3 mol L⁻¹ sodium carbonate on a watch glass and slowly add, drop by drop, 1 mol L⁻¹ HCl to the solution. Students will observe the evolution of gas from the solution. Here, the typical reaction of an acid on a carbonate, producing carbon dioxide, may be discussed.



Similar reactions can be carried out with small pieces of chalk and crushed sea shells.

Reactions Between Copper Metal and Silver Ions

Students are instructed to adjust the magnification to 10 or 15x and using a small piece of sandpaper or emery cloth, sand a 1-2cm piece of 12 or 14 gauge copper wire. This process removes any thin layer of oxides or chlorides and exposes pure wire. They then place a few drops of 1 mol L⁻¹ silver nitrate in the depression of the slide and place a 0.5cm piece of wire in the solution. After students have viewed the growth of needles and feather-like crystals, again a discussion of redox reactions between metallic atoms and cations of different elements may be appropriate.

Dissolving Potassium Permanganate in Distilled Water

This procedure is designed to allow students to observe crystals dissolving and to note the local colouring around a dissolving crystal. Any magnification between 10 and 30X may be used. Again, students place a few drops of distilled water in the depression of the slide and using a spatula, place one or two potassium permanganate crystals in the water.

These few experiments serve to illustrate how direct observations of chemical reactions with a microscope can be used to teach and

dramatise basic chemical principles. Many similar experiments can be developed to suit the needs of individual courses. After all, chemistry is an experimental science. Without excitement in the laboratory in the skills of observation, students may fail to understand and appreciate our discipline.

Journal of Chemical Education 62, 157 (1985)

We were recently contacted for assistance by a distraught parent whose child's shirt was spotted with black colloidal silver following an encounter with silver nitrate solution.

We supplied her with the ingredients of Farmer's Reducer and she subsequently reported a 100% success rate in removal of the offending stain. Her experience supported our own testing with this reagent for removal of colloidal silver from textiles.

Farmer's Reducer has been used since time immemorial in photography to correct over-exposed negatives. It consists of two solutions:

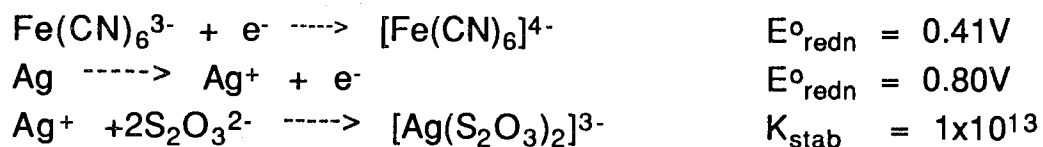
Solution A: Potassium ferricyanide, $K_3Fe(CN)_6$ - 7.5% W/V

Solution B: Sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$ - 25% W/V

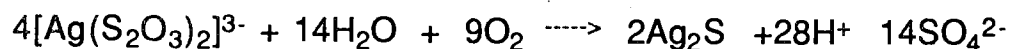
For stain removal equal amounts of the two freshly prepared solutions are mixed and applied to the material. The black colloidal silver dissolves and can be rinsed from the material. Thorough rinsing is essential in order to avoid the formation of black silver sulfide at a later stage.

In our test work we coated cheese cloth in 0.1M silver nitrate solution for five minutes. The cloth was removed and allowed to stand in sunlight for three weeks, at the end of which time it was uniformly stained to a delicate shade of black. A liberal application of Farmer's Reducer removed approximately half the stain within ten minutes and all of it within an hour.

The chemistry behind the process is the oxidation of silver metal to silver ion by the ferricyanide and the subsequent reaction of this ion with thiosulfate to give a soluble complex:



Incomplete rinsing of the material gives silver sulfide:



While the reduction potential of the ferricyanide reaction would appear to be too low to effect oxidation of metallic silver to soluble silver ion, the high stability constant for the thiosulfate silver complex ensures that the concentration of silver ion in solution remains low. Hence the reduction potential for the silver reaction is much lower than the E° value and the oxidation of metallic silver to silver ions will proceed.

For those who are theoretically inclined, the following calculation can be carried out.

Assume that 1g of metallic silver is present and that the volume of Farmer's Reducer is one litre.

	Moles Present	
	Initially	After Oxidation
Ag	0.01	0
Ag ⁺	0	0.01
[Fe(CN) ₆] ³⁻	0.11	0.10
[Fe(CN) ₆] ⁴⁻	0	0.01

For the complexing reaction, from the value of K_{stab} we can calculate

	Moles Present	
	Initially	After Oxidation
S ₂ O ₃ ²⁻	0.5	0.48
Ag ⁺	0.01	4.3x10 ⁻¹⁵

Applying the Nernst Equation

$$E_{redn} = E^\circ_{redn} - \frac{0.059}{n} \log \frac{[\text{reduced species}]}{[\text{oxidised species}]}$$

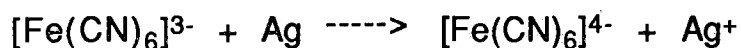
to the ferricyanide reaction, $[\text{Fe(CN)}_6]^{3-} + e^- \rightleftharpoons [\text{Fe(CN)}_6]^{4-}$

$$\begin{aligned} E_{redn} &= 0.41 - 0.059 \log \frac{0.01}{0.1} \\ &= 0.47V \end{aligned}$$

and for the silver reaction, $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$

$$\begin{aligned} E_{\text{redn}} &= 0.80 - 0.059 \log \frac{1}{4.3 \times 10^{-15}} \\ &= -0.05\text{V} \\ E_{\text{ox}} &= +0.05\text{V} \\ \text{Total } E &= E_{\text{redn}} + E_{\text{ox}} = 0.52\text{V} \end{aligned}$$

Thus the total reaction



will proceed.

Under normal circumstances the amount of metallic silver present per litre of solution will be far less than 1g and concentrations of Farmer's Reducer can be reduced but the reaction is slower. We found that a tenfold reduction in concentrations was still satisfactory, but the material required overnight soaking for complete removal of the silver stains. Even a 100 fold dilution performed adequately but two overnight soakings were required with fresh reagent being necessary for the second contact.

Precautions

Sodium thiosulfate solution is not stable over long periods and so should be freshly prepared.

Farmer's Reducer decomposes rapidly. The two solutions must be mixed together only immediately before use.

Farmer's Reducer will react with some dyes. Test the solution on an unimportant area before use and, if necessary, use a diluted solution.

Following stain removal the material must be thoroughly rinsed to remove the thiosulfate silver complex and unreacted reagents.

References

1. Farmer, H. 'Yearbook of Photography', p59 (1884), from C.B. Neblette, 'Photography, Its Principles and Practice', van Nostrand (1938), p365.

BURNING MAGNESIUM IN DRY ICE (SEN 1988, Vol. 37 No. 3)

Mark Cox, Cranbrook School

Introduction

A spectacular reaction which could be used to introduce oxidation/reduction material is the burning of magnesium in dry ice.



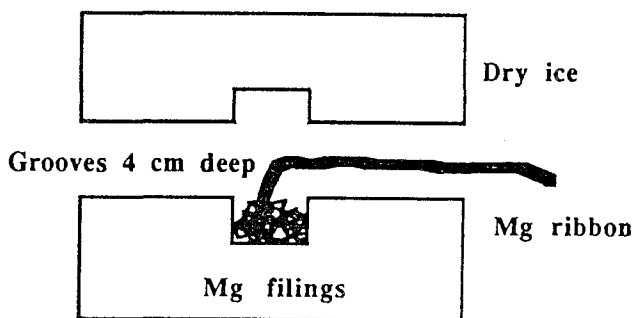
The reaction is extremely exothermic and should be carried out in a well ventilated area, well away from students. For the best effect the reaction should be done in a darkened room. The magnesium burns with an intense white flame and gas 'clouds' are forced out through the joint between the two blocks of dry ice. When the reaction has ceased, (20-30 seconds), a mixture of white MgO and black C can be observed.

1. Obtain two blocks of dry ice and create a pair of matching grooves, (at least 4cm).
2. Place a handful of Mg filings into the groove of the bottom block.
3. Wind approximately 30cm of clean Mg ribbon into fuse and insert it into the Mg filing pile.
4. Ignite the fuse, using a bunsen burner with a long rubber tube and then cover with the matching block.

Caution: Do not attempt the demonstration without having practised the procedure yourself. Inexperience could be potentially dangerous. Keep students well clear of the demonstration.

Discussion Question

Why have CO₂ fire extinguishers been barred from racing tracks since the introduction of Mg alloy car wheels?



HERE'S HOW YOU
CAN DO IT
IN
GEOLOGY

Section 3.

HERES HOW YOU CAN DO IT IN GEOLOGY

CONTENTS

Fossil Print Making	1
Three Dimensional Geological Models	2
Continental Drift for Junior Science	5
A Simulated Volcano	12
Fossils	13
Isostacy	14
Identification of Metamorphic Rocks	16
The Principles of Magmatic Differentiation	19
How Big is the Earth's Centre	22
Overhead Masters of Basaltic Rocks	24

FOSSIL PRINT MAKING (SEN 1979, Vol. 28 No. 4)

Lyn Thickett, Wiley Park GHS

Every science teacher has no doubt tried to stimulate interest in geological history by getting his/her students to make 'fossils' using plaster of Paris. The usual result is a few mediocre casts, a frustrated teacher and blocked up sinks. A less demanding experiment involves the production of carbon prints.

The process requires ground up black chalk, sheets of paper, hard leaves such as eucalyptus leaves and Vaseline. The hard leaves are lightly but thoroughly coated with Vaseline on both sides, then dipped in the ground chalk. The chalk coated leaves are then carefully pressed between two sheets of paper to form the 'fossil leaf print'. It is important to emphasise that this is NOT the method by which carbonated fossils are formed in nature and the results of this experiment give only a facsimile of the real thing.

Although the experiment is simple enough for all levels of ability, there are some hints which will make the experiment almost foolproof.

Hints

1. Don't let the students collect soft or hairy leaves as these do not coat very well.
2. Used duplicating paper can be recycled in this process.
3. Black boot polish from an applicator can be used instead of chalk and Vaseline.
4. Have a genuine carbonated fossil on display so that the students can compare their fossil prints with the original.
5. The finished prints can make an ideal display for a notice board.

THREE DIMENSIONAL GEOLOGICAL MODELS (SEN 1981, Vol. 30 No. 2)

T. Midgley, Doonside HS

Three dimensional structures are often difficult to visualise. These models provide excellent correlation techniques for senior and higher ability Year 10 students. (Refer Fig.1.)

Monocline with fault – 3-D Model

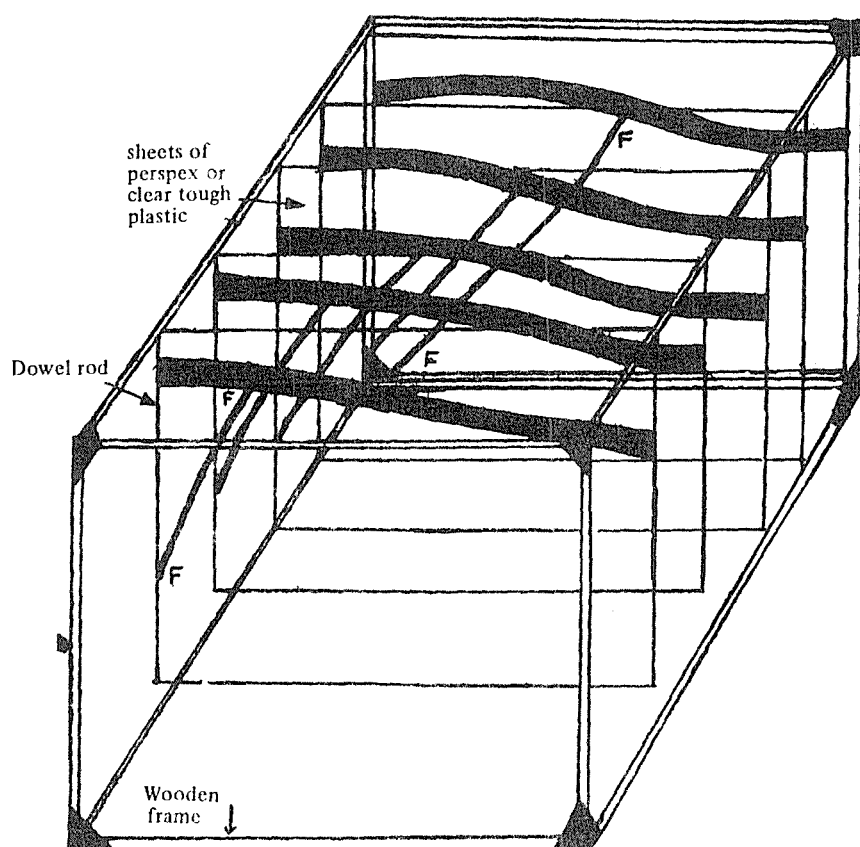


Figure 1.

The working unit consists of a wooden or metal frame, (size required depends upon storage space) upon which are hung geological x-sections. When viewed from the sides and ends a 3-D view is produced. Sections can be drawn by the pupils from "borehole data" supplied by —

The working unit consists of a wooden or metal frame, (size required depends upon storage space) upon which are hung geological cross-sections. When viewed from the sides and ends a 3-D view is produced. Sections can be drawn by the students from 'borehole data' supplied by:

- a) the teacher
 - b) geological exercise books (see references)
 - c) real data from mining companies, e.g. Mt. Isa Mines.
- Structures are drawn on with 'Texta' or OHP pens.

Suggestions

- a) Use contrasting, clear colours.
- b) Restrict any detailed sections, say, to 3-4 rock units.

At Doonside we have used OHP transparencies and strong, clear plastic sheets, but the use of clear perspex sheets is suggested for real clarity.

These can be reused by cleaning off with methylated spirits and any opacity which develops can be removed with 'Brasso' or some similar proprietary brand of metal cleaner.

Some suggestions for exercises are:

- correlation of rock units
- faults - vertical variation
- folds - lateral variation
- ore body shapes
- facies changes, i.e. lateral variation of units
- calculating ore body tonnages (Science Bulletin No. 25, p. 15)
- sections of volcanoes

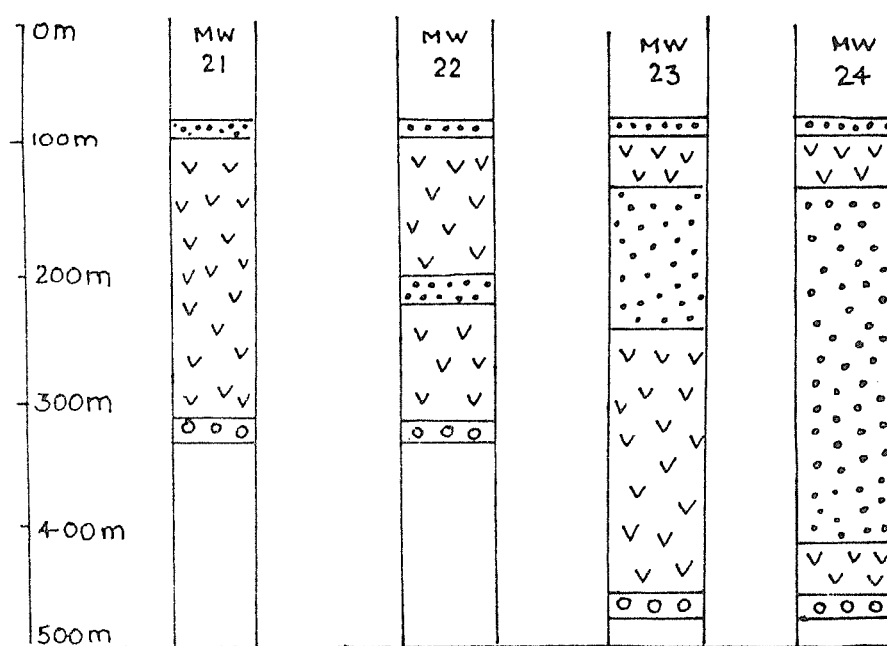


Figure 2.

An example of the procedure teachers might follow is given below.

1. Obtain n sheets of graph paper (n = number of cross-sections for your model).
2. Decide upon your scale, e.g. 1cm = 100 metres.
3. Draw whatever structure you would like to study on your first sheet (say Sheet A).
4. At regular intervals across the page 'drop' 'boreholes', eg. at 1,000metre spacing. (The result will be a pattern drilled grid.)
5. Transpose data from graph paper to columns (borehole cuts a bed, unit, fossil or structural feature; note depth on borehole log. (See Fig. 2.)
6. Draw other sections on your other sheets of graph paper, modifying the lateral variation if required. This can be done by laying one sheet over the previous section, held up on the window and traced with minor required differences, e. g. on attenuation of a fold.

Student Procedure

1. Student data sheets are issued. They now have to re plot the data given onto the plastic cross-sections with spirit pens (having been given a suitable scale).
2. Each student, or a small group, can be responsible for producing the finished section.
3. The group/individual places the section in the correct order in the frame.
4. Stand back, admire, realise that geology can be made interesting, constructively praise efforts, consider problems encountered, summarise the structural history.

Suitable books for data use are:

'Earth History in Maps and Diagrams', C.D. Ollier.

'Graded Exercises in Geological Mapping', K.R. Glasson and K.S. McDonnell.

'Coal Exploration, a Problem Solving Exercise in Geology', F.M.S. Tebbutt.

'Field Relations', The Open University.

Reprinted from Labscene, MW STA Journal.

CONTINENTAL DRIFT FOR JUNIOR SCIENCE (SEN 1983, Vol. 32 No. 3)

Tom Rozga, Sydney Technical HS

A. Gondwana Jigsaw - 1

About 250 million years ago all the continents were joined in one super continent, called Pangaea. The southern continents were called Gondwanaland. From 180 million years ago they have been moving apart. One of the first pieces of evidence for a super continent was that the coastlines could be matched to fit the continents together like a jigsaw. Alfred Wegener, a German scientist, proposed this idea in 1915.

1. Cut the continents out carefully and fit them into one continent which we will call Gondwanaland. The fit will not be perfect. Do not paste them onto your page as yet.

NOTE: When students cut the continents out they can paste them separately onto firm cardboard, then cut around the continents again. This makes it much easier to try to fit them together.

About 250 million years ago when the Gondwana continents were joined, certain parts of them experienced glaciation. The glaciers deposited large amounts of sediment, called till which formed the rock tillite. The part of the continents where tillite has been found is shown in the segments below. As a glacier moves it is capable of scratching and cutting deep grooves in the underlying rock. The direction of the glacial grooves tells geologists the direction in which glaciers moved. These directions are shown by arrows.

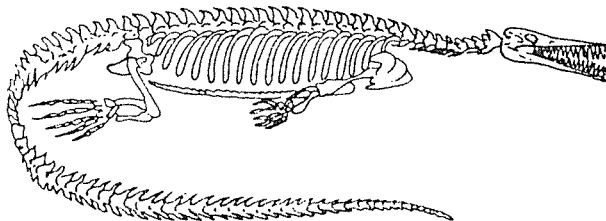
2. Colour the segments red, then cut them out and paste them onto the matching positions on the continents and check your fit. Can you see how this adds evidence that the southern continents were once joined as one continent?
3. Paste the continent Gondwanaland onto your page.

B. Gondwana Jigsaw - 2

In the previous activity a perfect fit was not possible. This is because the edges of the continents are not at sea level, but at the edge of the continental shelves and therefore below sea level. The continents below show the margins of their continental shelves by means of dashed lines.

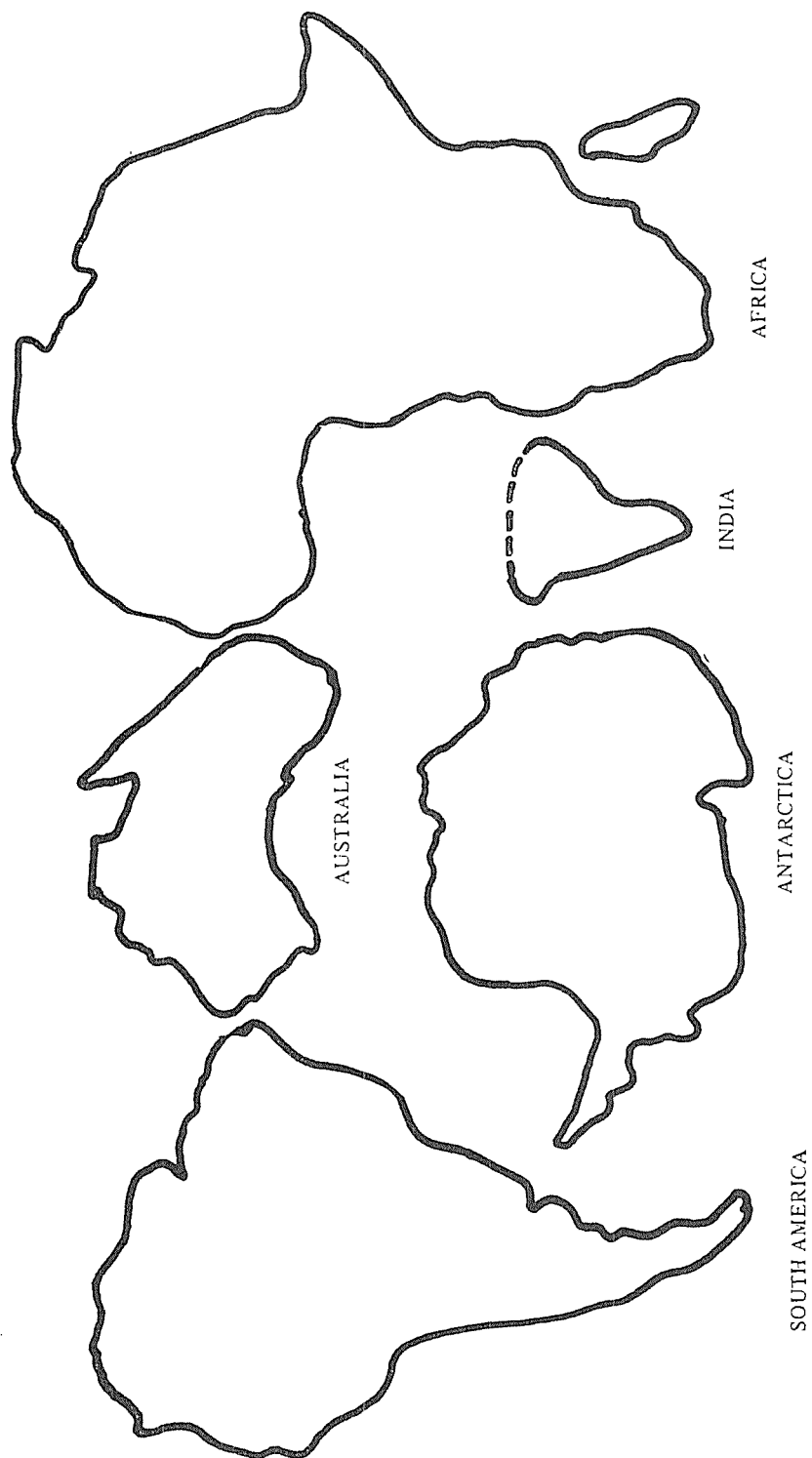
1. Cut out the continents around the dashed lines and arrange them on your page to obtain a better fit for Gondwanaland.

2. Colour the two segments below red. They represent the outcrop of the volcanic rock, basalt. The rock is about 100 million years old.
3. Cut the segments out and paste them onto the matching positions in Antarctica and Africa.
How does this add further evidence that the southern continents were once joined?
4. Colour the two segments below green. They represent the areas where the fossils of the extinct reptile, Mesosaurus, is found in Africa and South America. It lived 220 million years ago.
5. Cut the segments out and paste them onto the matching positions on Africa and South America.
It would be impossible for this reptile to evolve in isolation on these two continents at the same time. But Africa and South America were joined at the time it lived. Its existence in widely separated areas as fossils today is explained by Africa and South America drifting apart.
6. Paste the contents onto your page to form one super continent.

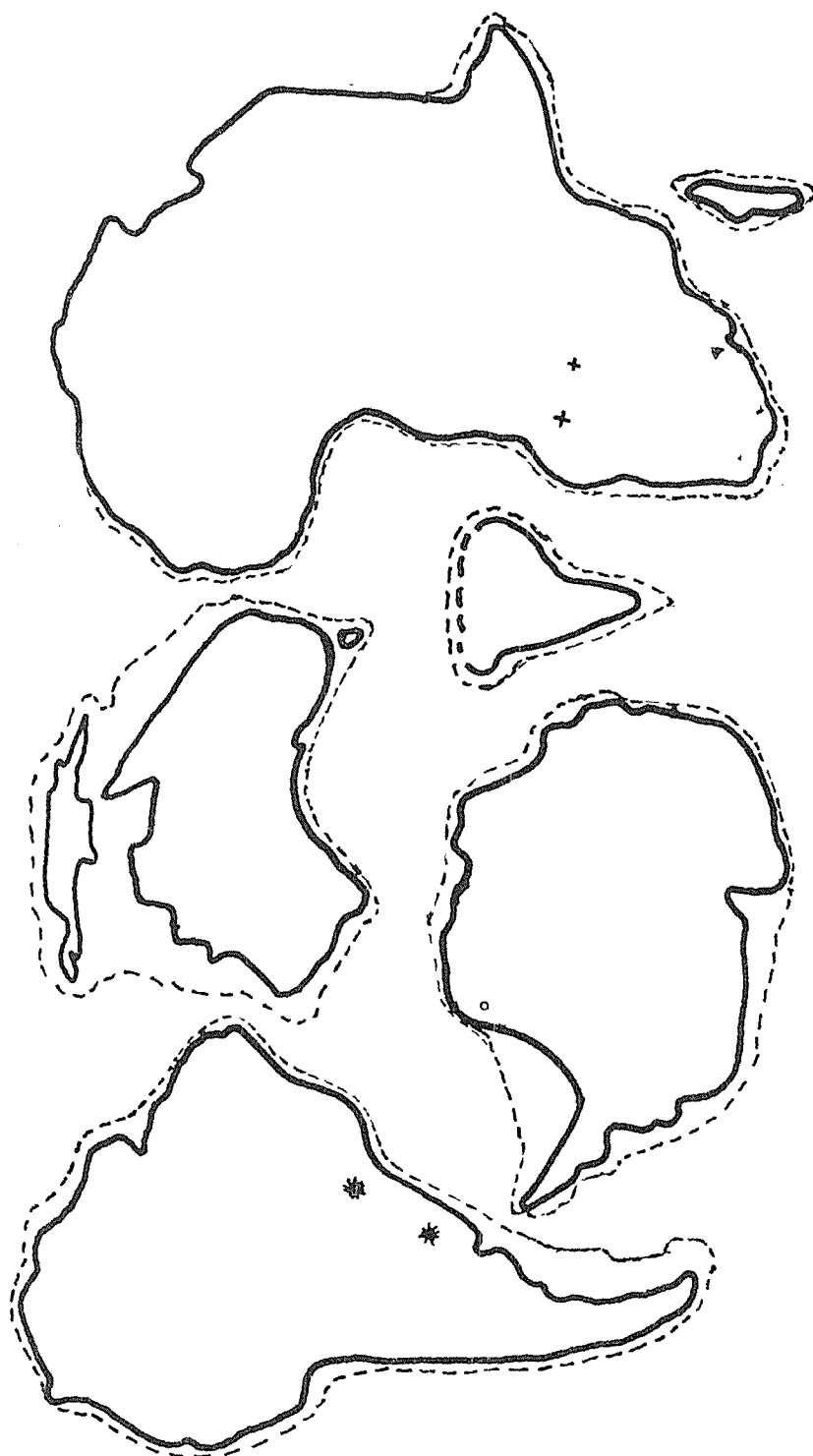


MESOSAURUS

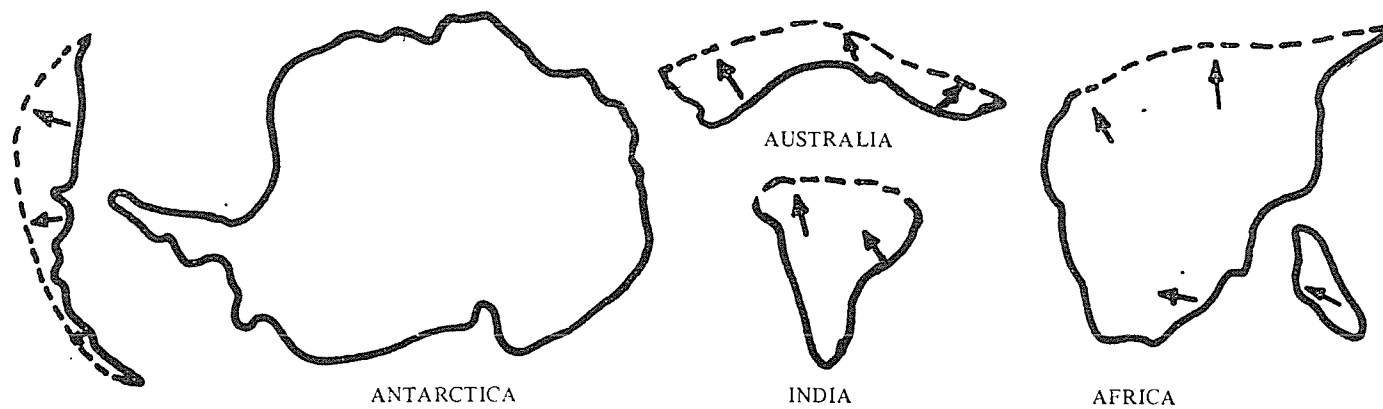
Paste the continents onto your page to form one super continent.



GONDWANA JIGSAW - 1 (Continents. Point 1)



GONDWANA JIGSAW - 2 (Continents, Point 1)



SOUTH AMERICA

ANTARCTICA

AUSTRALIA

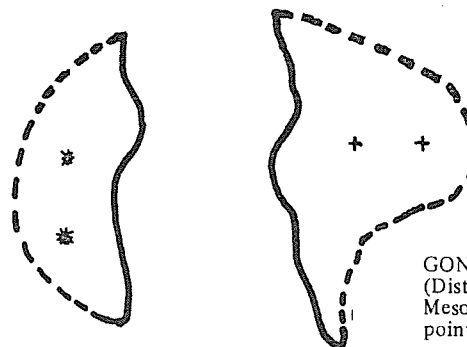
INDIA

AFRICA

SEGMENTS OF THE CONTINENTS WHICH HAVE EXPERIENCED GLACIATION AND
THE DIRECTION OF GLACIAL GROOVES. (GONDWANA JIGSAW - 1. Point 2)



GONDWANA JIGSAW - 2
(Basalt outcrops -
Points 2 and 3)

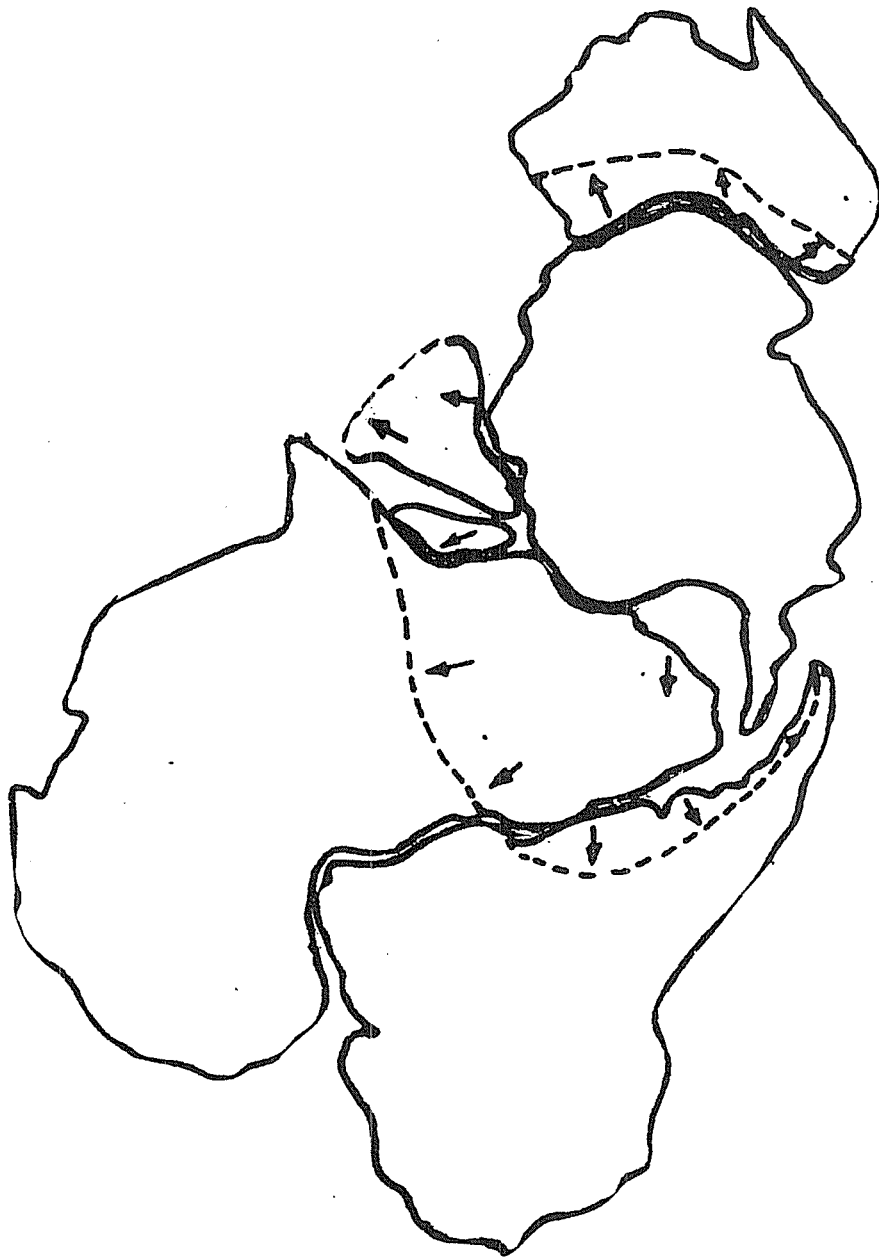


GONDWANA JIGSAW - 2
(Distribution of
Mesosaurus -
points 4 and 5)

AN OVERHEAD PROJECTION MASTER OF A POSSIBLE
SOLUTION TO GONDWANA JIGSAW - 2



AN OVERHEAD PROJECTION MASTER OF A POSSIBLE
SOLUTION TO GONDWANA JIGSAW - 1



A SIMULATED VOLCANO (SEN 1984, Vol. 33 No. 3)
N.G. Hickson, Tempe HS

My suggestion for a superb simulated volcano.

1. Make a mound of damp soil in an enamel laboratory dish. (**NOT** sand, damp soil!)
2. Form a crater in the mound with dimensions, say 10cm in diameter to a depth of 5cm.
3. Spread 2 or 3 tablespoons of Poolchlor granules into the crater.
4. Pour up to 40mL of brake fluid over the granules and stand well back.
5. Over the ensuing minute observe the reaction. The effects go close to the real thing, right down to the acrid fumes and residual 'lava' in the cone. With more reagents, a lava flow may even occur.

Warning: this is an **extremely dangerous reaction**. It must be shown outdoors, with students some 5 metres clear. Obviously, the reagent names should be withheld.

The damp, loose soil seems to be the catalyst for the volcano like effects. In sand you just get a rapid, exothermic reaction. I am familiar with the multitude of volcano demonstrations, but this is the best, in my opinion.

FOSSILS (SEN 1984, Vol. 33 No. 4)

George Kelen

An alternative technique for producing 'fossils' in the laboratory which can be applied to individual, self-paced work.

Equipment

Plasticine, bees-wax candle, test tube, peg, bunsen.

Methods

A. Fossil Footprints

1. Make a shallow basin in the plasticine (the end of a ruler is useful).
2. Make 'footprint' patterns in the bottom.
3. Melt wax in the test tube and allow to cool **but** remain liquid.
4. Pour the wax into the basin. Allow to cool and solidify.
5. Peel off the plasticine to reveal tracks and a cast of the tracks.

B. Casts and Moulds

1. Push flat the top of a blob of plasticine.
2. Push in and remove a shell or any other object to make a mould.
3. Melt wax in the test tube and allow to cool but remain liquid.
4. Pour the wax into the mould. Allow to cool and solidify.
5. Remove plasticine to reveal cast (and with care, the mould).

Comments

1. The materials are reusable.
2. The amount of possible mess is reduced.
3. Finer moulding and casting detail is possible.
4. Using the hot wax could be a hazard.

ISOSTACY (SEN 1986, Vol. 35 No. 2)
Dr. W. D. Roots, Macquarie University

Although isostacy is a vital concept in tectonics, little is being published on isostatic theory and the two original models (of Pratt and Airey) remain with us still. Both models are correct, but as special cases of a general model.

Isostacy explains that if forces pushing upwards at a given point within the earth equal the forces pushing downwards, then the material that presently occupies that point will remain unmoved vertically (though it may move horizontally). If, say, the 'down' force is greater than the 'up' force, subsidence will occur until enough material has moved down *past the reference point* to reduce the down force to the value of the up force.

The forces that upset isostatic equilibrium are due to tectonic, erosional, sedimentary, volcanic or other processes. Tectonic and volcanic processes are fast, relative to the slow gravitational up and down warping processes that bring about isostatic balance. It is this difference in rate that is responsible for the growth of mountains when continents collide, for example.

If the forces that correct an isostatic imbalance were as fast as the processes that cause mountains to form, then the mountains would be in isostatic balance, and rather smaller than is usual now. This is the case along all the mid-ocean ridges (MOR), where the material beneath the ridge is hot and able to flow rapidly. MOR elevation is the result of heating and thinning of the lithosphere, expansion and melting and consequent reduction in the density of the material under the MOR and so the elevation of the MOR crest until isostatic equilibrium is achieved. There is no isostatic anomaly over the MOR or over its flanks (past crests) as the cooling process is slow and gravitational subsidence, in response to the increase in density of the lithosphere, is no slower. The maximum height that mountains can attain depends on the difference in the speed of the tectonic and gravitational processes operating at that place.

A good class demonstration of isostacy goes as follows:

1. Draw a 5cm by 5cm grid on a blackboard.
2. Draw a cross-section of a continental margin (continental and oceanic lithosphere) on the grid, to a depth of 110km, showing internal structure on a grand scale (5km water, 5km sediments, 5km basalt layer, a 20km thick layer, a 50km thick lid - the lithosphere below the crust - 25km of asthenosphere for the

ocean side and as appropriate for the continental side). Use h and v scales of $10\text{km} = 10\text{cm}$.

3. Write the (rough) density in every square in four vertical columns evenly spaced across the board.
4. Sum all the densities in the columns and write this sum at the bottom of each column. (These represent gravitational forces of the material in each column, applied downward at the 110km level.)
5. Having seen the sums, select a figure that falls between the limits of the sums and declare this to be the lithostatic pressure at the 110km level (the upward force).
6. Now change the boundaries between the different layers of the cross-section by moving them up or down, making layers thicker or thinner, or change the densities you choose, until the (changed) sums all equal the lithostatic pressure. The rough cross-section you began with will be much modified in the process and will end up much closer to reality.

This exercise will leave you with a much clearer understanding of isostasy, but I suggest you do it alone before you try it on a class, so that your starting cross-section is reasonably close to reality.

IDENTIFICATION OF METAMORPHIC ROCKS (SEN 1987, Vol. 36 No. 1)

Kevin Burg, Benilde HS

Most Geology text books and their accompanying practical/laboratory manuals have good and easy to use schemes for identifying igneous and sedimentary rocks. However, there is a lack of any similar sort of schemes for identifying metamorphic rocks.

I have attempted to produce an easy to use dichotomous key for identifying the more common metamorphic rocks that are encountered in the senior Geology course.

I have modified one of the activities from the lab. manual of 'Perspectives of the Earth' to include this key. Your reactions, comments, suggested improvements would be appreciated.

Identifying Metamorphic Rocks

Purpose:

This activity is designed to introduce you to a system for identifying and describing metamorphic rocks.

Introduction:

Metamorphic processes are quite complex and difficult to simulate. Most of our information about metamorphism is derived from the study of metamorphic rocks in the field, in hand specimen and thin section. The classification of metamorphic rocks is also quite difficult because of the wide variety of metamorphic rocks. The make up of a metamorphic rock depends on three main criteria; the composition of the original rock, the kind of metamorphic change it has undergone and the degree of alteration it has experienced. However, a fairly simple classification system has been included in this exercise. As with all rock classification schemes, it is based on making careful observations of the TEXTURE and COMPOSITION of the rock.

Materials:

Metamorphic rock specimens, handlens, textbook.

Procedure:

1. For each specimen use the key below to identify the rock.
2. Record in a table the steps you took to identify the rock.
3. For each specimen identified, make a note of the following:
 - a) fabric - the way the mineral grains are arranged
 - b) grain size - measure or estimate
 - c) mineralogy - the minerals present and estimate their abundance
 - d) origin - what was the likely original rock?

Summary:

1. Describe the origin of foliated and non-foliated textures in metamorphic rocks.
2. List the foliated rocks in order of increasing grain size.
3. Account for this variation in grain size.

Key for Identifying Metamorphic Rocks

1. Is the rock foliated (i.e. does it have pronounced layering, banding, cleavage or alignment of minerals)?
If yes go to 2; if no go to 18.
2. Does the rock appear to split easily into layers?
If yes go to 3; if no go to 4.
3. Is the rock fine grained?
If yes go to 6; if no go to 5.
4. Does the rock contain abundant mica flakes, or other flaky or elongated minerals?
If yes go to 7; if no go to 8.
5. Does the rock contain abundant, easily visible mica flakes, or other flaky or elongated minerals?
If yes go to 7; if no go to 13.
6. Does the rock have a perfectly smooth, fine grained cleavage surface?
If yes go to 9; if no go to 10.
7. The rock is SCHIST. Name it according to its most abundant minerals.
8. Does the rock contain alternating bands of light and dark crystalline minerals?
If yes go to 11; if no go to 15.
9. The rock is SLATE.
10. The rock is PHYLLITE.
11. Is the rock composed of >50% amphibole minerals?
If yes go to 16; if no go to 12.
12. The rock is GNEISS. Name it according to its most abundant minerals.
13. Does the rock have a waxy feel or appearance?
If yes go to 14; if no go to 15.
14. The rock is SERPENTINITE.
15. Does the rock contain >50% amphibole minerals?
If yes go to 16; if no go to 25.
16. The rock is AMPHIBOLITE.
17. Does the rock react vigorously with dilute acid?
If yes go 18; if no go to 19.
18. Does the rock contain >90% calcite?
If yes go to 20; if no go to 21.
19. Does the rock have a spotted appearance?
If yes go to 23; if no go to 24.

20. The rock is MARBLE.
21. The rock is CALC-SILICATE HORNFELS.
22. Does the rock appear to have bands or lenses of light and/or dark minerals?
If yes go to 12; if no go to 13.
23. The rock is SPOTTED HORNFELS.
24. Is the rock composed of >90% quartz?
If yes go to 25; if no go to 13.
25. The rock is QUARTZITE.
26. Does the rock contain appreciable amounts of a white fibrous mineral and green and brown minerals?
If yes go to 21; if no go to 27.
27. The rock is HORNFELS. Name it according to its most abundant minerals.

**THE PRINCIPLES OF MAGMATIC DIFFERENTIATION (SEN 1988,
Vol. 37 No. 4)**

Richard Cramp, Marist College North Shore

- Aim:**
1. To develop a better appreciation for the processes and principles involved in magmatic differentiation.
 2. To demonstrate how, as crystallisation progresses, the chemical composition of a melt gradually alters.
 3. To illustrate the order of crystallisation affects the integrity of the crystals which form, as available space for growth diminishes.

Theory: A mineral is, in essence, a chemical compound which is stable, in crystalline form, within a limited range of conditions. Thus minerals may be distinguished from one another not only by their chemistry but also by their 'freezing point', (that is, when they begin to form crystals).

A magma is a complex but homogeneous mixture of minerals and as such has no single point at which crystallisation takes place. Rather it has a range of crystallisation, (i.e. over several hundred °C). Over this range minerals will crystallise successively as the temperature decreases.

As each compound crystallises out of the melt the composition of the magma changes. Compounds which crystallise early are effectively removed from the magmatic mixture, leaving the way for the next compound to begin crystallisation; and so the process repeats itself.

These principles are clearly represented in Bowen's Reaction Series which not only classifies minerals by composition and structure but also by their crystallisation temperatures.

Those compounds which crystallise early have the freedom to develop a perfect form, whereas those that develop later lack the freedom of space in which to grow and consequently the form diminishes in quality with continued crystal growth.

- Method:
1. Prepared solutions of $\text{CoCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$, $\text{K}_2\text{Cr}_2\text{O}_7$ and NaCl are used.
N.B. a) concentrations as low as 0.8M are quite adequate
b) other salts may be used, but check for precipitation first.
 2. Samples of each solution are poured into separate petri dishes and labelled. These are the controls by which the crystalline salts may later be identified.
 3. These dishes are placed in a sunny, protected position where the crystals may develop by slow evaporation.
 4. Prepare mixtures of any two or more of the prepared solutions in 1. in 80mL beakers, using approximately equal proportions. (Ensure that the solutions are thoroughly mixed to form a homogeneous mixture.)
 5. The homogeneous mixtures are then poured into petri dishes, labelled left in a sunny, undisturbed corner to crystallise by evaporation. (This may take a day or two depending on the concentration of the prepared solutions.)
- N.B. The following combinations yield the best results:
- | | |
|---|---|
| a) $\text{K}_2\text{Cr}_2\text{O}_7 + \text{Cu}(\text{NO}_3)_2$ | b) $\text{FeCl}_2 + \text{NaCl}$ |
| c) $\text{CoCl}_2 + \text{NaCl}$ | d) $\text{Cu}(\text{NO}_3)_2 + \text{NaCl}$ |
| e) $\text{K}_2\text{Cr}_2\text{O}_7 + \text{Cu}(\text{NO}_3)_2 + \text{NaCl}$ | |
6. The students will be able to observe a sequential crystallisation of the salts in solution and if two or more coloured salts are used, a gradual change in colour will also be observed indicating the changing chemistry of the solution, e.g. mixing copper nitrate and potassium dichromate yields a transparent green solution. As the copper nitrate crystallises to form its characteristic blue crystals, the remaining solution becomes yellower, as is expected of potassium dichromate solution, indicating the changing chemical composition of the solution. Eventually, orange potassium dichromate crystals will form.

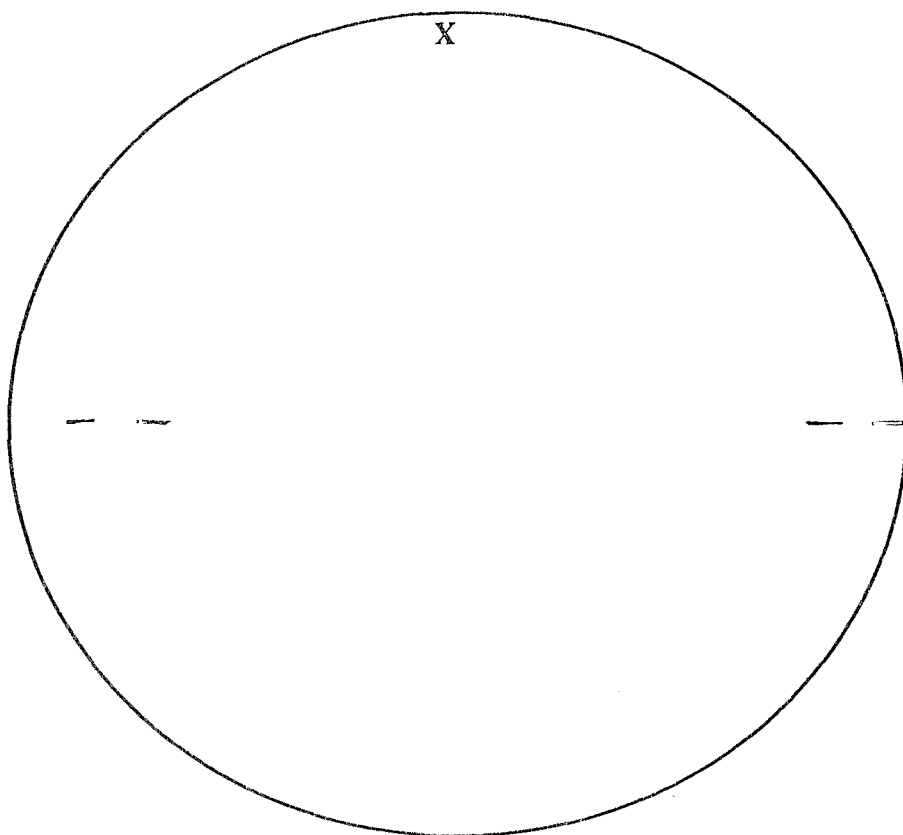
7. Once the solution has completely crystallised the petri dish may be inverted and held up to the light. The effect is like looking at a thin section through a petrological microscope or a photo-micrograph. The order of crystallisation may be determined as well as other relationships.
8. By placing polarising films in front of and behind the petri dish, it is possible to demonstrate the application PPL and XPL in petrogenesis.

In essence this experiment sets up easily affordable 'thin sections' and a very simple and cheap petrological microscope which can be used to demonstrate the principles of petrography and petrogenesis in petrology.

HOW BIG IS THE EARTH'S CENTRE? (SEN1988, Vol. 37 No. 4)

Using Light Rays to Model the Earth's Core

1. Set up the ray box to give one narrow light beam
2. Place semi-circular prisms from the kit in the inner circle.
This area represents the Earth's Core
3. Shine the narrow light ray so that it passes through the point labelled X. Trace the path of the ray as it goes through the Earth. This shows the path taken by an earthquake wave through the Earth.
4. Trace at least ten different rays. All must pass through the point labelled X.



Questions

1. Do any rays travel directly through the Earth?

2. Is there an area in which no direct light rays which pass through the point labelled X are seen? Mark this zone by shading it on the diagram and labelling it "Shadow Zone".

3. Suggest where the term "Shadow Zone" might have originated.

How Can the Size of the Earth's Core be Measured?

The simplest answer to this question is it cannot....at least not directly, but earthquakes give geologists a useful measuring stick for the Earth.

What to Do:

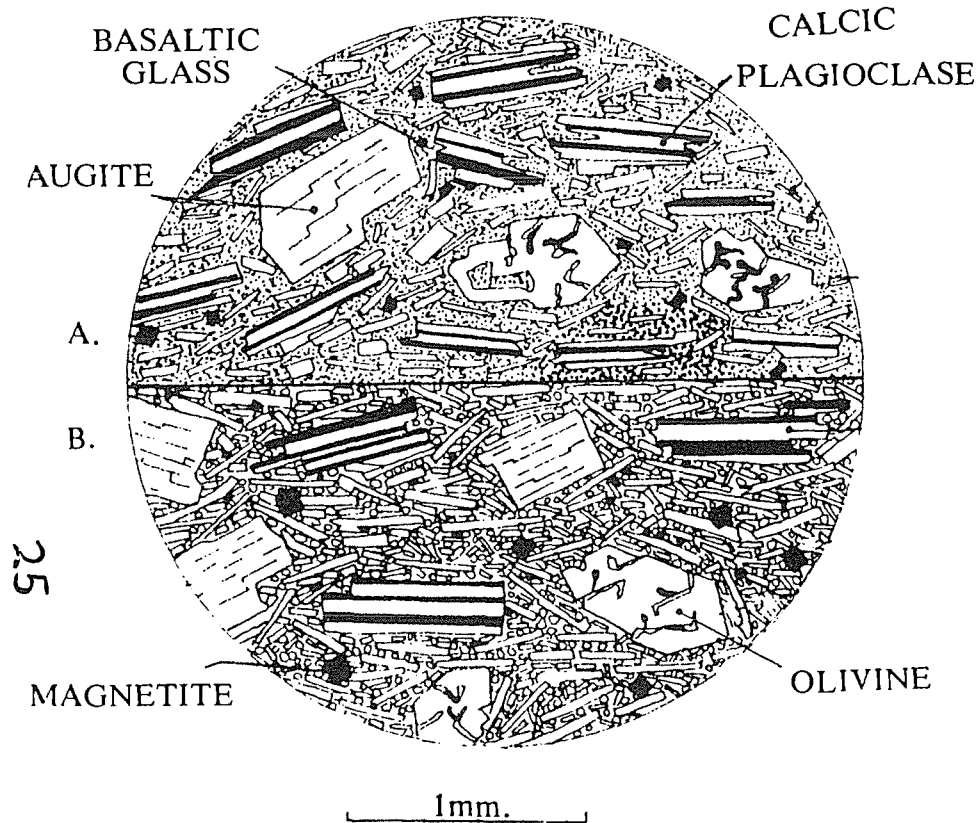
1. Measure the size of the "Earth" and "Core" in the last activity. Calculate the percentage of the Earth which is taken up by the Core. Also measure the angle at which the shadow zone starts. Record this information in the table below:
2. Draw another outer circle which is larger or smaller than the first. Find the start of the shadow zone for this "Earth" and again calculate the percentage of the Earth which is taken up by the core and record the data.
3. Repeat till you have at least six data points.
4. Draw a graph of percentage core against shadow zone starting angle.
5. The shadow zone of the real Earth starts at an angle of 143 degrees. Use your graph to find the percentage core you would expect.
6. The Earth has a diameter of 12,730 kilometres. What size should the core be?

TABLE OF RESULTS:

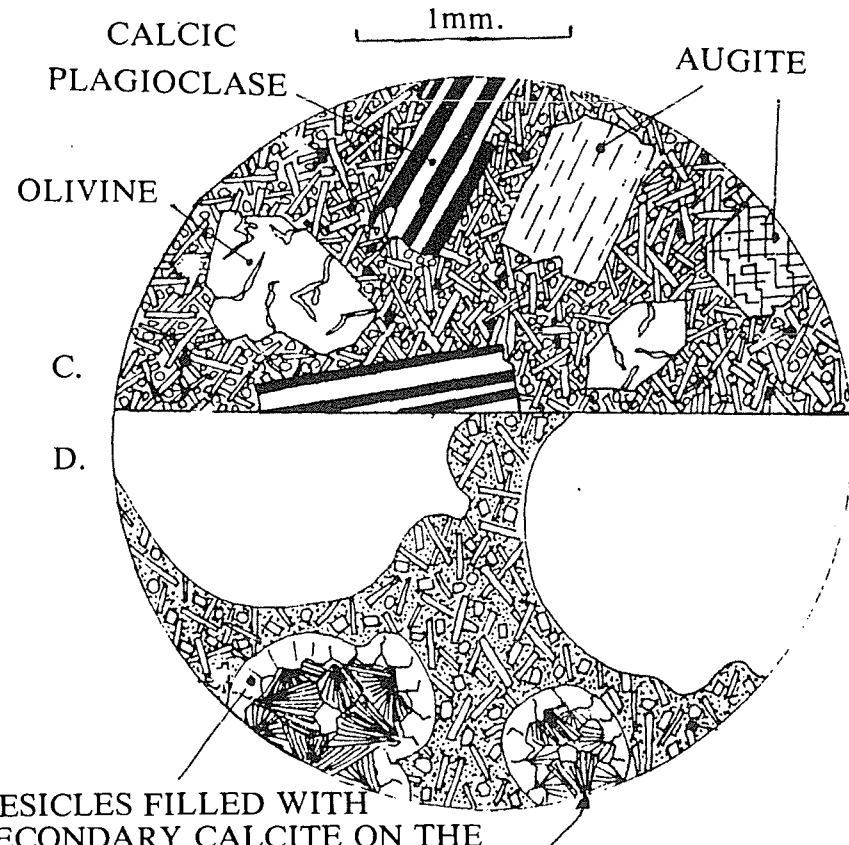
Size of inner circle "Earth"	Size of outer circle "Core"	Percentage Core	Shadow Zone	Starting Angle

CONCLUSION: The Earth's Core is about _____ km in size.

OVERHEAD PROJECTION MASTERS OF PHOTOMICROGRAPHS OF BASALTIC ROCKS



PHOTOMICROGRAPHS A AND B CONTAIN PHENOCRYSTS OF CALCIC PLAGIOCLASE, AUGITE AND OLIVINE. IN B THE GROUNDMASS IS FINELY CRYSTALLINE, CONTAINING LATH SHAPED PLAGIOCLASE CRYSTALS, GRANULES OF AUGITE AND SOME OLIVINE. THE GROUNDMASS IN A CONTAINS BASALTIC GLASS. NOTE THE ALIGNMENT OF CRYSTALS INDICATING A FLUIDAL FABRIC



VESICLES FILLED WITH SECONDARY CALCITE ON THE MARGINS, FOLLOWED INWARD BY CHALCEDONY. SUCH FILLED VESICLES ARE CALLED AMYGDULES.

IN C THE GROUNDMASS SHOWS AN INTERGROWTH OF THE CONSTITUENT MINERALS. WHILE SUCH A FABRIC IS STILL COMMON IN FLOWS, IT IS CHARACTERISTIC OF BASALTIC MAGMA WHICH COOLS RAPIDLY IN THIN DYKES. IN D SMALL CAVITIES CALLED VESICLES, FORMED BY EXPANDING GASES IN THE LAVA, ARE PRESERVED. SUCH A BASALT IS SAID TO POSSESS A VESICULAR TEXTURE.

OVERHEAD MASTERS OF BASALTIC ROCKS

HERE'S HOW YOU
CAN DO IT
IN
PHYSICS

Section 4.

HERES HOW YOU CAN DO IT IN

PHYSICS

CONTENTS

Poor Physics in Determining Acceleration Due to Gravity	1
Sunset Colours and Blue Skies	6
Balloon in a Bottle	8
Recycle Broken Thermometers	9
Using the Digital Counter/Timer	10
Making Your Own Air Table	13
Accurate Measurement of Length for Year 7	15
Motor Driven Stroboscope	16
Shoot Out	18
Overload Protection for Current Meters	19
Acceleration Made Simple	20
The Salt Fountain Oscillator	22
A Technique for Producing Sketches and Line Diagrams	23
Lasers	28
Multi-Level Practical Test for an Electric Circuit Unit, Using a 'Black Box' Maze	43
How Strong is Paper?	48

Measuring Magnetic Fields Using a Hall Effect Device	4 9
Observing the Sun	5 4
Additional Experiments on Polarisation of Light for Elective 2 - Wave Nature of Light	5 5
Using a Laser and Plastic Fibres to Transmit Speech	5 8
The Microwave Kit and Laser	6 3
Circular Motion on an Inclined Track	6 6
A Two Slit Interference Experiment	6 8
Voice Transmission on a Light Beam	7 2
Hydroelectric Generator	7 5
Projectile Motion	8 0
Recycled Car Parts in the Physics Laboratory	8 1
The Voltage Divider Common Emitter Transistor Amplifier	8 7
Experiments with Multitap Coils	9 1

POOR PHYSICS IN DETERMINING ACCELERATION DUE TO GRAVITY

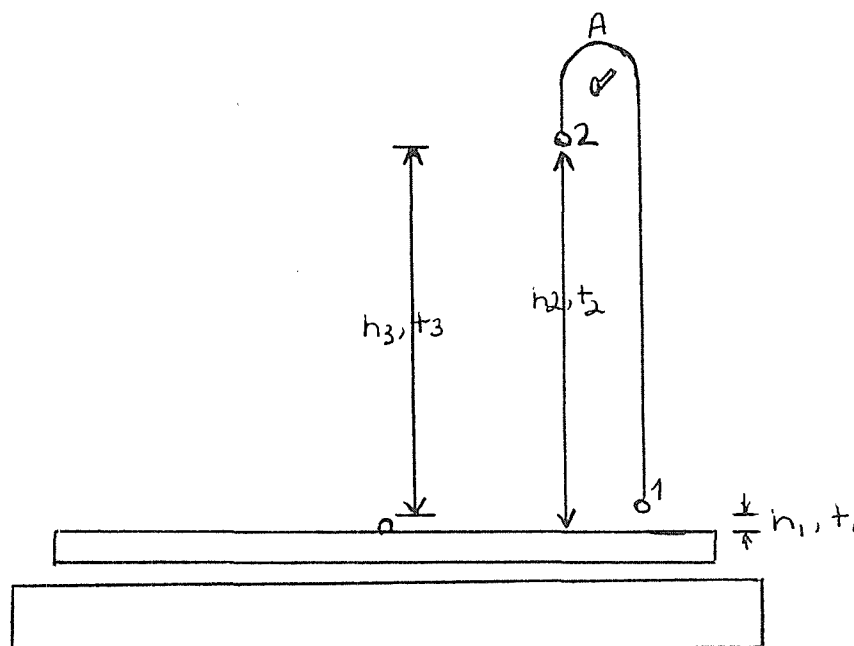
(SEN1979, Vol. 28 No. 4)

Geoff Marsh, Kyogle HS

For some years now, I have found that my students were never able to find a 'good' value for acceleration due to gravity using balls and a turntable. The method is one of several described in Project Physics Unit 1 Experiment 7 which I ask students to choose between to determine g .

I have analysed the results on individual repetitions of the experiment in an attempt to find the major source of error. Unfortunately these analyses have not been very fruitful. Recently I analysed the experimental method in a more general form. The result is that my future students will **not** be using the algebra as suggested in the experimental notes to determine g . Now, why should that be?

Consider the experimental arrangements shown below.



Two balls connected by a string are suspended over a turntable and along a radius of the turntable. On the turntable are a circle of paper and one of carbon paper. As the turntable rotates the string is burnt at A and the balls drop leaving clear marks on the paper. The angle between these marks, and the speed of rotation of the turntable are used to determine the time of fall and hence g.

The purpose of my analysis was to find the expected error in the measured value of g.

Consider the following:

Ball 1 takes a time t_1 to fall h_1 to the turntable

Ball 2 takes a time t_2 to fall h_2 to the turntable

Ball 3 takes a time t_3 to fall h_3 to the initial position of Ball 1

The method which most students use is that the difference in time of arrival of the balls at the turntable ($t_2 - t_1$) is taken to be about the same as the time for ball 2 to fall a distance h_3 (ie. $t_2 - t_1 = t_3$).

Originally I accepted this as a reasonable approximation, but as the following analysis shows, it is far from a reasonable approximation.

Let $h_2 = xh_1$ where $x > 1$.

From $d = \frac{1}{2}at^2$:

$$t_1 = \sqrt{\frac{2h_1}{g}} ; \quad t_2 = \sqrt{\frac{2h_2}{g}} \quad \text{and} \quad t_3 = \sqrt{\frac{2(h_2 - h_1)}{g}} = \sqrt{\frac{2h_3}{g}}$$

$$\text{Then } t_3 = \sqrt{\frac{2(xh_1 - h_1)}{g}} \quad \text{and} \quad t_2 - t_1 = \sqrt{\frac{2xh_1}{g}} - \sqrt{\frac{2h_1}{g}}$$

$$\text{That is } t_3 = \sqrt{x-1} \sqrt{\frac{2h_1}{g}} \quad \text{--- (1)} \quad \text{and} \quad t_2 - t_1 = (\sqrt{x} - 1) \sqrt{\frac{2h_1}{g}} \quad \text{--- (2)}$$

Now t_3 is the exact time of fall of ball 2 to the initial position of ball 1 (i.e. through a distance $h_3 = h_2 - h_1$). Also $t_2 - t_1$ is the exact difference in time of arrival of the balls on the turntable.

From equations (1) and (2) above:

$$\frac{t_2 - t_1}{t_3} = \frac{(\sqrt{x} - 1) \sqrt{\frac{2h_1}{g}}}{\sqrt{x - 1} \sqrt{\frac{2h_1}{g}}}$$

$$\text{OR: } t_2 - t_1 = \frac{\sqrt{x} - 1}{\sqrt{x - 1}} t_3 \quad \text{--- (3)}$$

Now the value of g calculated by students is :

$$g' = \frac{2h_3}{(t_2 - t_1)^2}$$

The relationship between this value and g can be found by substituting from equation - (3)

$$g' = \frac{2h_3}{\left(\frac{\sqrt{x} - 1}{\sqrt{x - 1}} t_3 \right)^2}$$

$$\text{ie. } g' = \frac{x - 1}{(\sqrt{x} - 1)^2} \times \frac{2h_3}{t_3^2}$$

$$\text{In fact } g = \frac{2h_3}{t_3^2}$$

and so the value g' is larger than g by the factor

$$\frac{x - 1}{(\sqrt{x} - 1)^2}$$

In actual experiments, values of x could range from about 8 to 100 depending on the delicacy of the turntable. That is, it is reasonable to expect that;

$h_1 = 2\text{cm}$, $h_2 = 16\text{cm}$ at one extreme,

to $h_1 = 0.5\text{cm}$, $h_2 = 50\text{cm}$ at the other extreme.

Then the values for g which we would expect the students to calculate are tabulated below:

Table 1

x	$\frac{x-1}{(\sqrt{x}-1)^2}$	Expected Calculated Value of g $g' = \frac{x-1}{(\sqrt{x}-1)^2} \cdot g \text{ (ms}^{-2}\text{)}$		Expected % Error
8	2.09		20.5	109
10	1.92		18.8	92
20	1.57		15.4	57
30	1.455		14.2	45
40	1.37		13.5	38
50	1.33		13.0	33
60	1.30		12.7	30
70	1.27		12.5	28
80	1.25		12.3	26
90	1.24		12.1	23
100	1.22		12.0	22

Even for the extreme of dropping one ball 50cm, the other 0.5cm, students should then calculate a value for g which is 22% higher than the accepted value. If $h_1 = 0.5\text{cm}$, $h_2 = 100\text{cm}$, (your turntable, not mine!) then students should be expected to calculate g as 11.3ms^{-2} - a 15% error.

What if we try to counter these effects, by taking $t_2 = t_2 - t_1$ because t_1 is small? That is, assume that the time measured by the turntable is equal to the time of fall of ball 2.

By arguments similar to those above, the value of g to be expected is:

$$g = \frac{x}{(\sqrt{x}-1)^2} \frac{2h_3}{t_2^2}$$

and the values of g calculated by this method are tabulated in Table 2.

Table 2

x	Expected Calculated Value of g			Expected % Error
	$\frac{x}{(\sqrt{x} - 1)^2}$	$g^e = \frac{x}{(\sqrt{x} - 1)^2} \cdot g$	(ms ⁻²)	
8	2.39	23.5		139
10	2.14	21.0		114
20	1.66	16.3		66
30	1.50	14.7		50
40	1.41	13.8		41
50	1.36	13.3		36
60	1.32	12.9		32
70	1.29	12.6		29
80	1.27	12.4		27
90	1.25	12.2		25
100	1.23	12.1		23

Clearly this alternative is less acceptable than the method students are asked to use.

Many approximations we make are reasonable and lead to acceptable experimental results. But when a method results in an expected error of 20% (or worse) then the method must be unacceptable. Consequently, I would recommend that this method should not be used.

There is light at the end of the tunnel! A suggestion made to me by Mr. I. Cooper of Sydney Teachers College is well worth using. It is simply that:

$$\text{Since } t_1 = \sqrt{\frac{2h_1}{g}} \quad \text{and} \quad t_2 = \sqrt{\frac{2h_2}{g}}$$

$$\text{then } t_2 - t_1 = \sqrt{\frac{2}{g}} (\sqrt{h_2} - \sqrt{h_1})$$

This last expression is quite simply rearranged to give an exact value of g:

$$g = \frac{2 (\sqrt{h_2} - \sqrt{h_1})^2}{(t_2 - t_1)^2}$$

I don't believe that this expression is too daunting for Year 11 students and all quantities on the right hand side are measurable. It is a simple matter to make sure that the calculations students perform for this experiment are those needed to solve this last equation and I strongly recommend that the necessary changes be made.

SUNSET COLOURS AND BLUE SKIES (SEN 1980, Vol. 29 No. 2)

Margaret O'Donnell, Dip. Ed. student, Sydney Teacher's College

Concepts and Uses

Explanation of blue skies and red sunsets

Scattering of light by particles

White light is a mixture of colours

Colloidal particles

Tyndall effect

Equipment

Aquarium (no smaller than 30x15x15cm)

Slide projector

Aluminium foil or cardboard slide (see below)

Soap solution (1 litre; see below)

Sheet of white cardboard (50x20cm)

Measuring cylinder

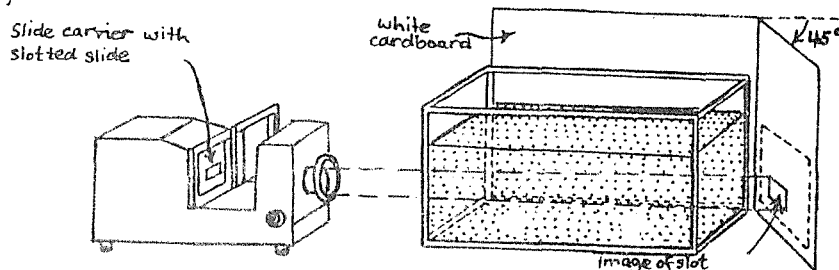
Preparation

1. Soap solution. Dissolve a level teaspoon of Lux soapflakes in a little hot water; dilute to 1 litre.
2. Slide. Cut a horizontal slot (2x1cm) in a piece of cardboard or aluminium foil and fit it into the carrier of the projector.

Procedure

1. Fill the aquarium with clear water to about 2/3 of its capacity.
2. Darken the room and direct the projector beam through the water and focus it, so that it forms a sharp image of the slot on the white cardboard. (See Figure 1.)
3. Add soap solution 50mL at a time to the water in the aquarium and stir to ensure mixing. Before and after each addition invite students to record colours observed in the water and on the screen.

Fig. 1



Explanation

The colloidal particles in the soap solution can scatter light and thus show a strong Tyndall effect. These particles scatter light at the blue end of the spectrum more efficiently than light at the red end. As light encounters an increasing number of particles, more and more colours are scattered out of it, so that the emerging light changes from yellow to orange and finally to red. Colloidal particles (dust, smoke) in the air close to the horizon scatter and hence block, blue light, whilst permitting red light (longer wavelengths) to pass through. Hence, as the sun approaches the horizon, more and more of the blue light is scattered and the sun and the sky appear redder.

BALLOON IN A BOTTLE (SEN 1980, Vol. 29 No. 2)

The two litre 'fizzy' drink bottle has potential for a variety of uses in the classroom. The following activity demonstrates some principles of air pressure.

Hang a long balloon inside the bottle. Stretch the open end of the balloon over the rim of the bottle opening and secure it by screwing on the bottle cap. Punch a hole in the cap with a nail. Punch or drill a hole in the bottom of the bottle.

Inflate the balloon inside the bottle by blowing into the hole in the cap or by sucking air out of the hole in the bottom. Note what happens when you try to inflate the balloon while holding one finger over the other hole. What happens if you cover either hole after the balloon is inflated? What are the effects of changing the size of either or both of the holes?

Since the plastic bottle can be squeezed and popped back to its original shape, it also can be used for an inhalation/exhalation demonstration.

RECYCLE BROKEN THERMOMETERS (SEN 1980, Vol. 29 No. 2)

Broken thermometers usually have mercury left in the bore hole. Because this mercury does not move with temperature change, the 'reading' on the scale remains constant. Broken thermometers are therefore ideal for practising or testing skills in thermometer readings. The answers remain the same and can be self corrected by the student or checked remotely by the teacher.

Several broken thermometers, with sharp edges taped for safety, can be permanently mounted on a portable board to be used as a practice or testing station. Other broken graduated lab apparatus can also be adapted to provide examples of number lines.

Note: If mercury should spill out of a thermometer, all mercury should be picked up at once. Any traces in cracks in the floor should be covered with a chemical ('HgX' powder is available from Government Stores) that will coat the mercury and reduce the vapour pressure.

USING THE DIGITAL COUNTER/TIMER (SEN 1980, Vol. 29 No. 2)

Ray Ceccato, Wade HS

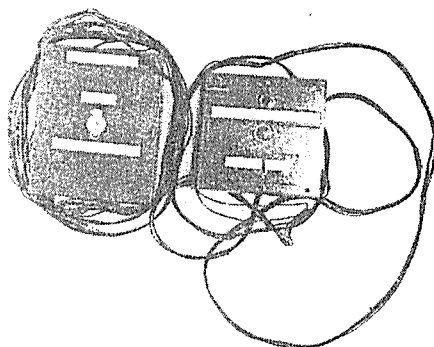
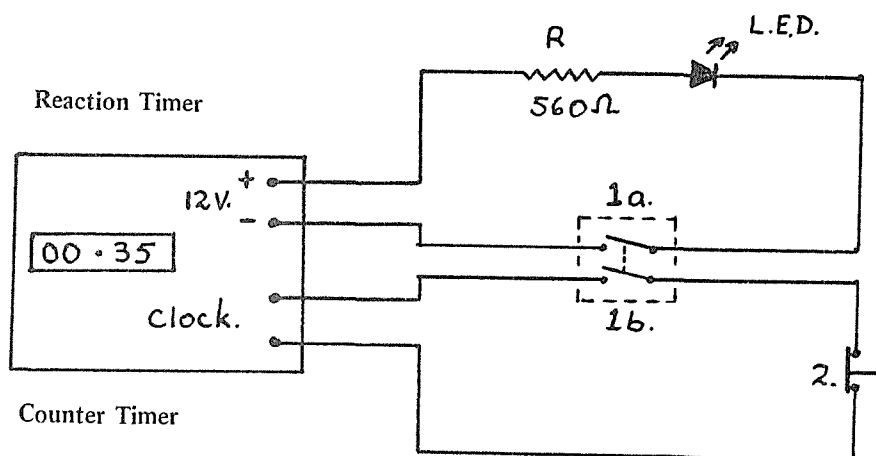
If your school has a digital counter/timer you have probably used it for measuring acceleration due to gravity, or as a reaction timer. Usually this means setting up a temporary circuit each time. This problem can be overcome if permanent modules are constructed.

Reaction Timer

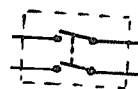
Materials Needed

1. Double pole double throw switch
2. LED and current limiting resistor
3. Bell wire
4. Push button switch
5. Two boxes to house the apparatus

Circuit Diagram



D.P.D.T. switch.



1a LED on.

1b Clock on.

2. clock off.

} Simultaneously.

Procedure for Operating

1. Push button switch must be closed to complete clock circuit
2. DPDT switch is rigged so that the clock and LED are switched on simultaneously
3. The person being tested presses the push button to stop the clock when the LED lights
4. After reading the reaction time, the push button switch, the DPDT switch and the digital counter/timer are reset

Applications

1. Biology - finite time taken for nervous transmission
2. Physics - importance of reaction time in driving
3. Just for fun

Measuring the Acceleration Due to Gravity

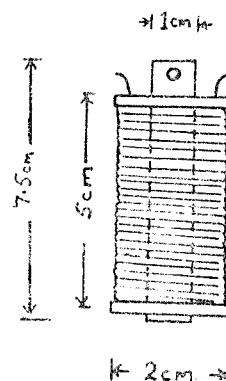
Materials Needed

1. Double pole double throw switch
2. Bell wire
3. Magnet and keeper or other device which will open when hit by a steel ball
4. Electromagnet
5. Optional, steel stand to support apparatus
6. Boxes to house equipment

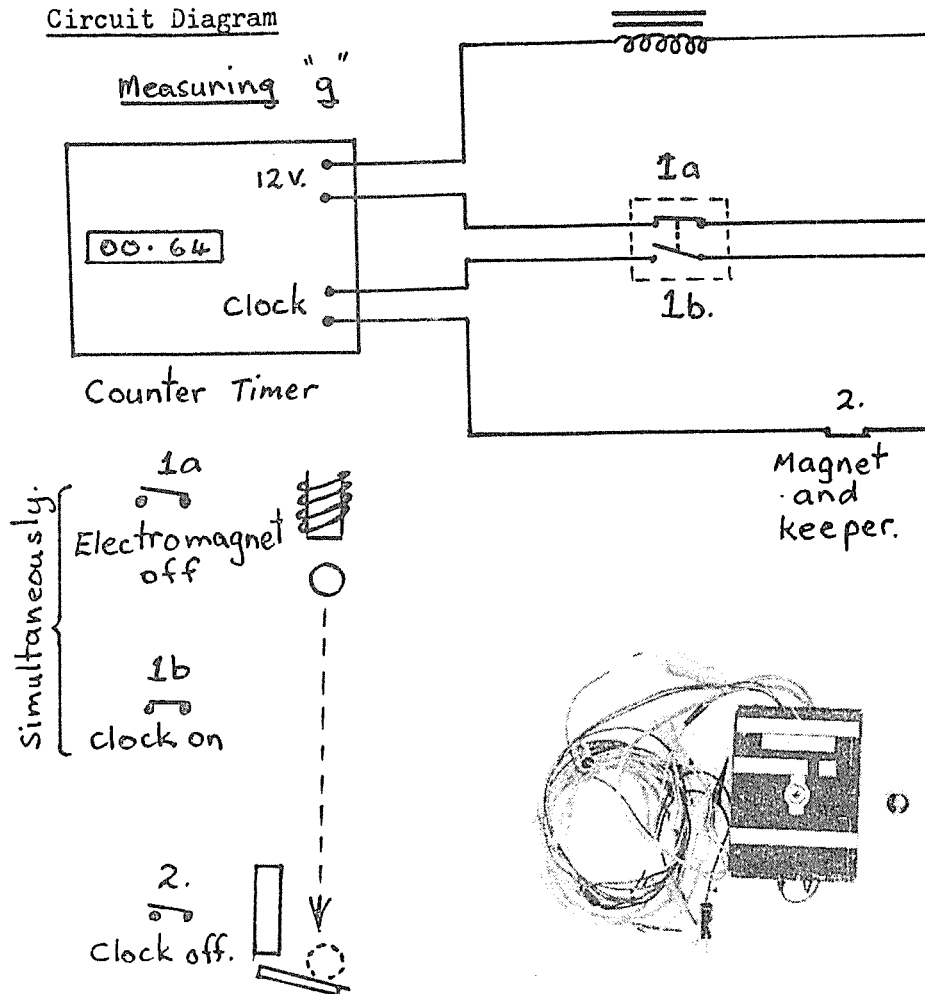
Construction of Electromagnet

A school type electromagnet will not work from the 12V, 0.25 output of the counter/timer, so a special electromagnet must be constructed. This consists of about 450 turns of 24 SWG enamelled copper wire wound on a 1cm diameter iron core. The 22SWG enamelled copper wire supplied to schools should be suitable, even though it may make the electromagnet slightly bulkier.

Note: a suitable electromagnet may be available on school requisition, Item No. 992630. Alternatively, a 'school type' magnet can be used, run from a separate 6V DC power supply. - Ed.



Circuit Diagram



Procedure

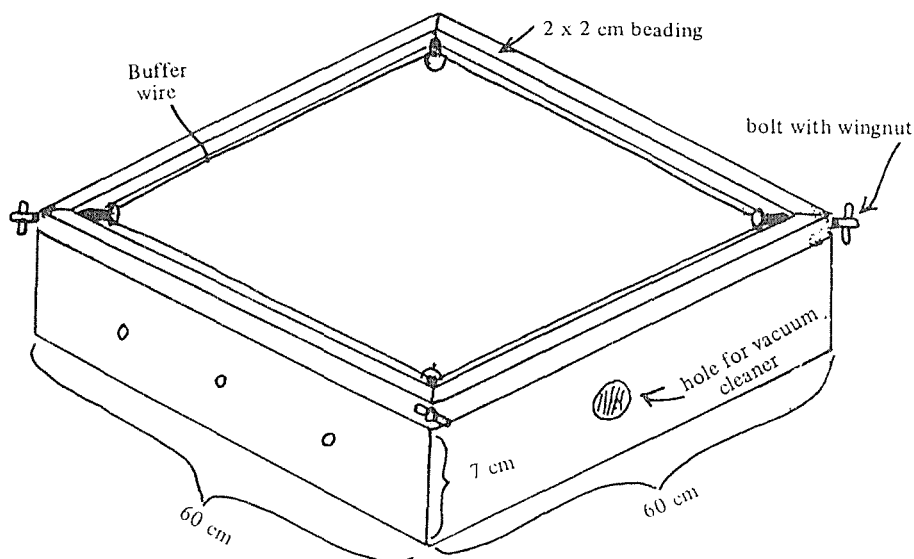
1. The DPDT switch is rigged so that the electromagnet is on and the clock is off.
2. Operating the DPDT switch switches off the electromagnet and turns on the clock simultaneously.
3. When the steel ball strikes the keeper, the clock circuit is broken and the clock stops. Acceleration due to gravity may then be computed from $S = 1/2gt^2$ since S and t can both be measured.

Errors can be minimised if the electromagnet is designed to just hold the ball in place, so minimising any time lag between switching off the magnet and the ball falling. Slips of paper between the ball and the magnet can serve this purpose. S should be made as large as possible to reduce timing errors. This arrangement is much easier to use than the Venner clock, in which the current to the electromagnet is interrupted each time the clock passes zero. As well, the setting up time is reduced.

MAKING YOUR OWN AIR TABLE (SEN 1980, Vol. 29 No. 3)

C.J. Craven, Canowindra HS

In a number of experiments in senior physics, an air or bead table is a very useful if not essential item. To buy one of these already manufactured can be very expensive. While bead tables are cheaper, they have disadvantages, especially with the beads. I have found that an air table can be manufactured for little expense or expenditure of time.



The full scale dimensions of the table are 60cm x 60cm x 10cm. The first stage is to make your basic frame of timber, about 7cm x 2cm, which is glued, butted and nailed together. Better joints can be used but they are not necessary. Onto this is glued and nailed a sheet of masonite.

Now comes the exciting part! Using a 2.0mm drill you now drill holes every 1.5 to 2cm apart over the entire surface. (This might be a good job for a misbehaving student.) When this is completed, another sheet of masonite is glued to the base.

The next step is to attach beading around the edge. This is done with wood approximately 2cm x 2cm and is nailed around the top edge of the box. Drill a hole through this beading at each corner approximately 7mm in diameter. Through each of these holes you can then place a 5cm x 6cm cuphead bolt with a wing nut. Behind the cup head on each bolt, drill a hole about 2.0mm so that wire may be threaded through.

Take a piece of monochord wire or unravel a strand or two of picture hanging wire through all four bolts. Pull it fairly tight and join the ends. The wing nuts can then be used to adjust the wire to the correct tension. You now have a buffer which the puck can bounce off.

The last step is to cut a hole in the side of the table big enough to put a vacuum cleaner hose in. You may find, when you start it up, that the masonite will bow out due to the air pressure. I have found that you can drill a number of 10mm holes around the sides until enough air can escape to allow the masonite to stay flat. I have found that petri dishes with elastic bands around the edges make good pucks and bounce off the wire nicely. Sizes shown here are only used because of the size of the material at hand. I have found it a convenient size, however, for both work and storage.

**ACCURATE MEASUREMENT OF LENGTH FOR YEAR 7 (SEN 1980,
Vol. 29 No. 4)
Graeme Cox, Karabar HS**

Aim

To familiarise students with an accurate method of measurement of length (either in place of using a micrometer or as an introduction to a micrometer).

Method

Students (in groups of 2 or 3) are issued with a 'G' clamp. They then wind the 'G' clamp to the fully open position and measure the distance between the two jaws, to the nearest millimetre. The students then count the number of turns required to close the jaws together.

By dividing the total length by the number of turns, students now have a reasonably accurate method of measuring length. This is obtained by counting the number of turns required and multiplying this by the length of each turn. Students then measure a number of objects, several times.

Questions

1. Does one article always measure the same length?
2. Why do errors occur?
3. How would you improve or modify a 'G' clamp to improve its accuracy for measuring length?
4. Draw a diagram to show how these would be incorporated to make a micrometer. (Then compare students diagrams with an actual micrometer.)

One of the most intractable devices currently used in the physics laboratory is the motor-driven stroboscope. Attempts to select an accurate disc speed using the strobe pattern supplied (Figure 1) are often foiled by changes due to disc orientation, motor heating, etc. This problem can be overcome using paddles.

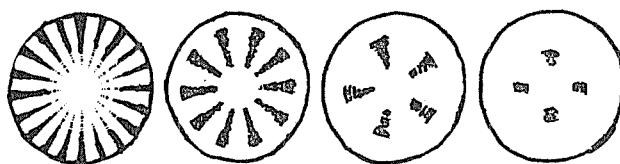
Initial attempts to control the disc rotational speed involved building a combined precision voltage and current source with a high degree of control resolution (see circuit diagram, Figure 2). It was expected that, since the motor speed (and hence the disc speed) was proportional to the current flowing through the motor windings, the current source would be more effective than a voltage source in controlling the motor's speed. These expectations were confirmed, but although the disc speed could be accurately set with a current source of about 1 milliamperes resolution, this speed changed markedly with disc orientation. It was then concluded that the dynamic and frictional characteristics of the motor were dominating the situation. (Note that the precision current/voltage source would be worth building for other experiments in which a constant current or voltage supply is required)

In order to dampen the characteristics of the motor (or to provide a well-behaved load for the power supply/motor system to work against), flat paddles were fitted to the strobe disc as in Figure 3.

Testing the arrangement showed instant success. The speed of the stroboscope was found to be so insensitive to motor current that an ordinary 10ohm laboratory rheostat in series with a standard laboratory power supply gave excellent control and stability. Also the strobe speed was insensitive to disc orientation. The method would probably be just as successful with camera-mounted strobes.

If the paddles are detachable they can be varied in size by cropping them equally with scissors. It would then be possible to have sets of paddles that tuned the stroboscope to operate at the various required strobe rates.

STROBE CALIBRATION CHART



REVS PER SEC	5	10	20	25
SECS PER EXPOSURE	2	1	05	04

Figure 1

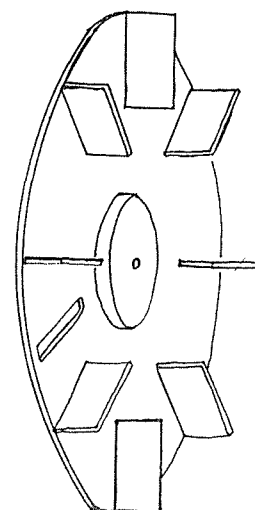


Figure 3

Parts Distributors

All resistors and capacitors—
 Sheridan Electronics, Redfern
 Dick Smith
 George Brown
 Radio Despatch

Mains Switch, DP/DT Illuminated—Dick Smith.

Bridge Rectifier MDA 3504—Silicon Valley, St. Leonards.

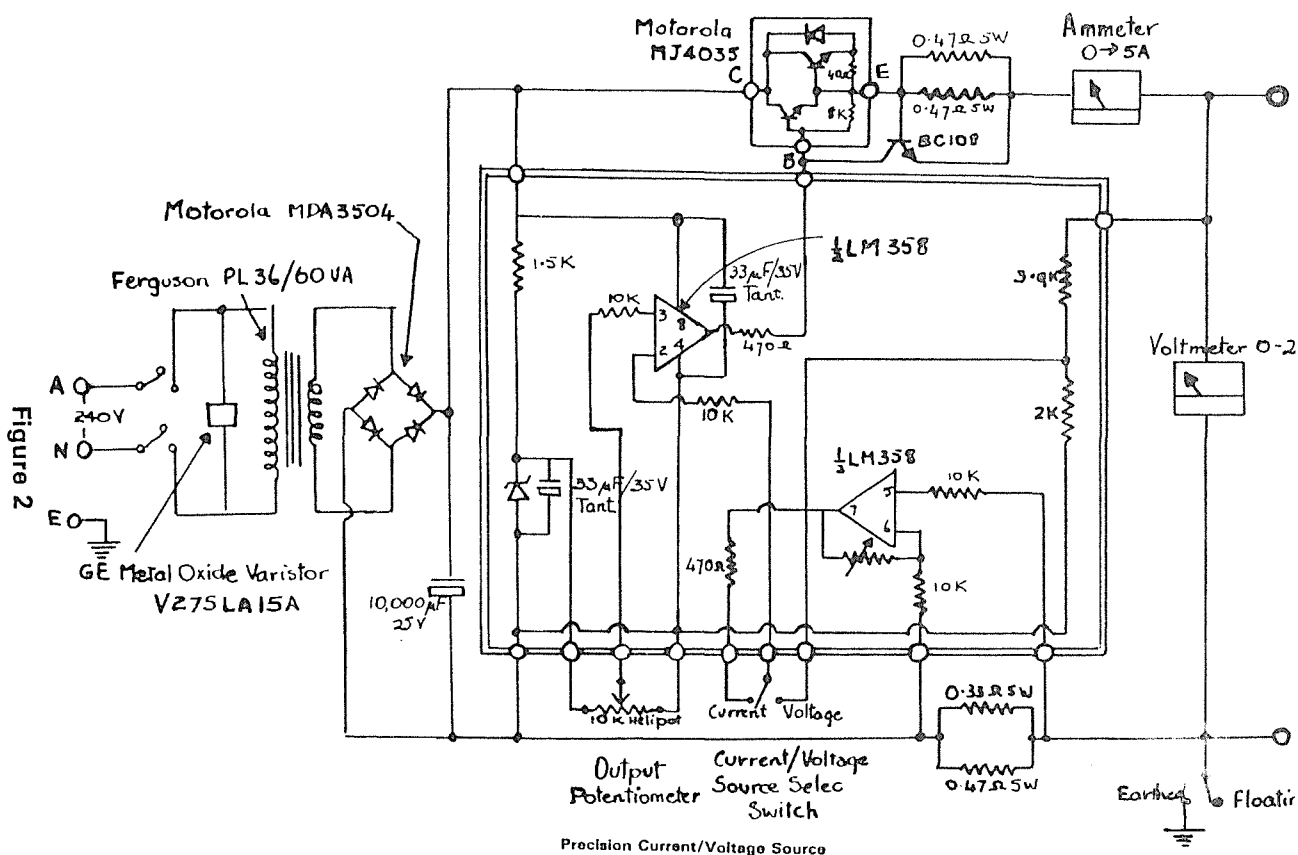
LM358 Operational Amplifier—Semtech, Lane Cove.

Ammeter, Voltmeter and BC108 or similar—Dick Smith.

Power Darlington MJ4035—Silicon Valley.

Ferguson Transformer PL 36/60 VA—Sideband Electronics, 213 Hawkesbury Road 'or' Box 23, Springwood, 2777.

Phone: (047) 54-1392.



SHOOT OUT (SEN 1980, Vol. 29 No. 4)

Genella Gerardi, Cheesequake School, New Jersey

Have you ever had students shooting rubber bands in class while they were supposed to be doing something else? This disruptive behaviour can be channelled into a learning activity. Divide the class up into pairs of students and give each pair rubber bands of uniform size, a centimetre ruler and a meter stick. Provide the following instructions:

1. Hold the ruler on the edge of the desk.
2. Hook the rubber band on the end of the ruler and pull back to the 12cm mark.
3. Let the rubber band go.
4. Measure flight distance with the metre stick.
5. Repeat four times and record data.
6. Repeat the above, but pull rubber band back to the 16cm mark and then the 20cm mark, five times each, and record the data.
7. Average the distances for each pull.
8. Record the averages for each student pair and determine the class average for each pull.
9. Make a list of variables affecting differences in flight distance.
10. Graph the stretch of the rubber band and the distances travelled.

Sixth graders have enjoyed this activity immensely. The shoot out can be repeated using rubber bands of different sizes and comparing the results. Also the ruler can be placed at different heights such as on a low table and a high bookcase and measurements taken.

OVERLOAD PROTECTION FOR CURRENT METERS (SEN 1981, Vol. 30 No. 2)

Mike Gunnourie, Sydney Teachers College

It doesn't matter how much you tell them, they still connect ammeters, mill- and microammeters and galvanometers directly across power supplies and burn them out. Some models have built in fuses but most don't. Current meters at Sydney Teachers College have been overload protected simply and cheaply by removing the base plate and replacing one of the leads from the terminals to the meter movement with a piece of fine wire. Proper fuse wire might serve but, having none handy, it was found that a single strand of the wire inside normal plastic covered hookup wire would burn out at currents from about one to five amps, depending on the brand. (Test a piece with the desired length - about five centimetres- using a power supply and ammeter to determine its maximum current rating.) Even microammeters will tolerate an ampere or so for an instant without damage.

The resoldering job is simple enough to be given to some students and perhaps making the person who 'blew' the meter fix it would have some educational merits.

J.B. Muir

The concept of acceleration is often made more difficult by the complexities of the analysis of ticker tapes. This same analysis tends to obscure the outcome of investigation of accelerations down inclined planes and the relationship between force, mass and acceleration.

Provided that some work has been done to show that the acceleration down an inclined plane, or that produced by a constant unbalanced force, is uniform, we can use the following technique for more routine measurements.

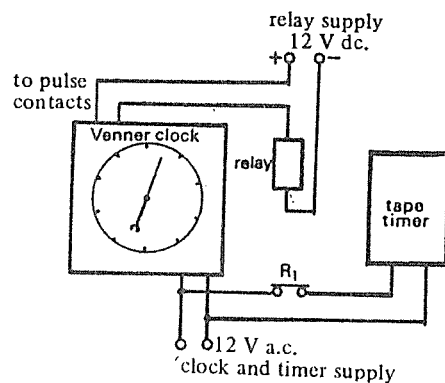


Figure 1. Tape timer control circuit.

Assuming acceleration to be the change in velocity in one second then if we measure two velocities at the beginning and end of a 1s interval:

$$\text{acceleration (ms}^{-1}\text{)} = \frac{\text{final velocity (ms}^{-1}\text{)} - \text{initial velocity (ms}^{-1}\text{)}}{1\text{s}}$$

This can be achieved in practice using the Mk 1 Venner clock to control the low voltage AC supply to a tape timer as shown in Figure 1.

During the 1s sweep of the Venner clock when set to run continuously, the pulse contacts are open between zero and 0.1s and closed between 0.1s and 1s. This mode has to be reversed to operate the tape timers so that dots are produced on the tape for 0.1s at 1s intervals. To do this a 12V relay, fitted with a pair of normally closed contacts, is energised via the pulse contacts. These contacts

(R₁) switch the 12V AC supply to the tape timer, causing it to print six dots at 1s intervals on the tape. If the timer is vibrating at 50 Hz, the five spaces produced represent 0.1s.

This arrangement is most conveniently operated from one power supply giving both the 12V AC and the 12V DC. This is switched on when a run is to be made. A possible analysis of results is shown in Figure 2.

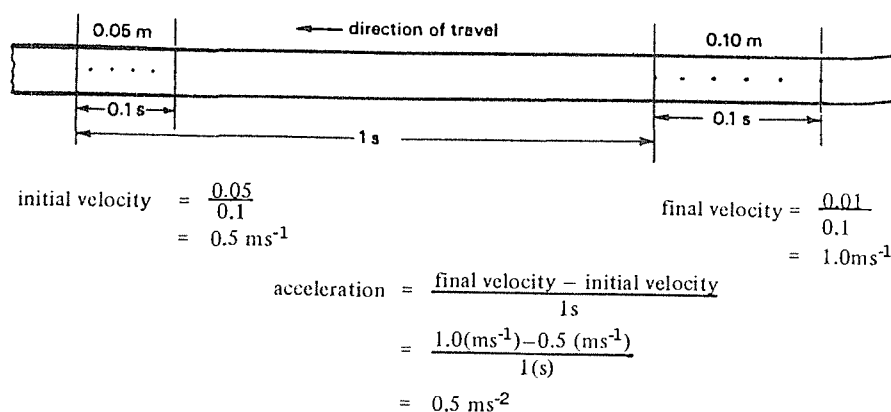


Figure 2. Typical tape, and analysis of data.

In practice a friction compensated plane has to be chosen which is long enough for the run to take more than 1 second.
 (Reprinted from School Science Review 58, 497-498, March 1977.)

THE SALT FOUNTAIN OSCILLATOR (SEN 1981, Vol. 30 No. 4)

Ray Linabury, Canterbury BHS

This is a simple but elegant demonstration which makes use of the density difference between salt and fresh water.

1. Pour cold water into an 800mL beaker until it is about 3/4 full.
Obtain;
a paper cup and place a pin hole in the bottom of it. Prepare a salt solution about equal to half the volume of the cup, using 1 1/2 to 2 teaspoons of salt. Stir the solution thoroughly so that all the salt dissolves. Add enough dye to colour the salt solution.
2. Lower the cup into a beaker whilst , at the same time, pouring the dyed salty solution into the cup. Adjust the cup so that the water level inside is as close as possible to the water level outside. Fix the clip into position by taping some glass rods to its sides so that it is supported by the edge of the beaker, as shown in Figure 1a.

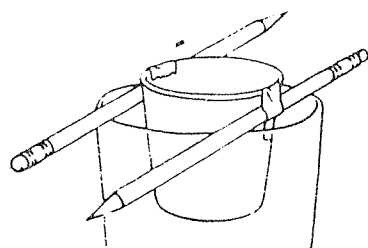


Figure 1a.

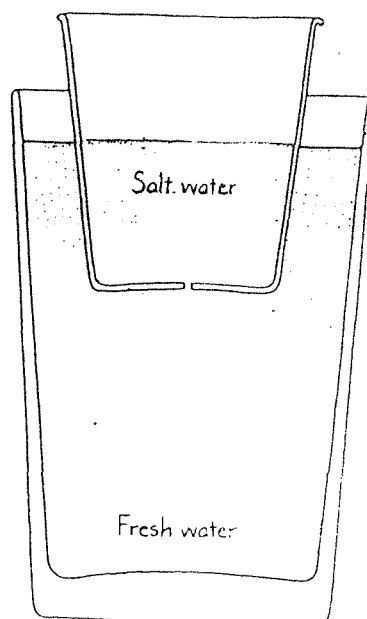


Figure 1b. *The basic salt oscillator*

You may need to place a small weight of some kind on top of the cup to keep it down. When the cup is in position a stream of coloured salty water will begin to flow out of the pinhole. The coloured water will collect on the bottom of the beaker due to its greater density, as shown in Figure 1b. After several minutes the flow will stop for a few seconds and the oscillation will begin. The period of oscillation varies according to the size of the hole in the paper cup. However a pinhole generally gives a flow of about 20 seconds and a period in which nothing appears to be happening of about 30 seconds. Oscillations will continue for up to 12 hours.

A TECHNIQUE FOR PRODUCING SKETCHES AND LINE DIAGRAMS (SEN 1981, Vol. 30 No. 4)

C.L. Fogliani and I.T. Townsend, Mitchell CAE

A picture is worth a thousand words and students certainly come to understand the gist of an experiment if they can see a realistic picture as well as printed instructions. The trouble is normal photographs suffer from certain inherent disadvantages:

- * they are usually continuous tone rather than black and white; this means that they generally need sophisticated equipment and considerable expertise for copying or duplicating
- * they often contain too much information; this can be of two types - a distracting background or too much complexity in the subject itself; often this can only be solved after much trial and error with lighting, camera angles, backgrounds, etc.

The technique to be described overcomes some of these problems; the resulting pictures are high contrast, black and white, greatly simplifying reproduction. Only the required amount of detail need be recorded in the final product. This is largely in the hands of the teacher within the limitations of the method.

The first requirement is to produce a photograph of the apparatus or technique of which the sketch or line diagram is desired. One does not need to be a good photographer nor does one need a lot of photographic equipment to do this. We use a SLR fitted with standard lens and electronic flash. A perfectly suitable set up is a polaroid camera loaded with 105 (B&W) film. Colour film is not suitable. The technique or equipment is photographed from a variety of angles. It is desirable to use a brightly lit area or a flash unit so that a small aperture can be used at hand-held speeds (1/30 - 1/60sec). The film is processed in the normal way and prints produced on resin-coated paper of the same size as required for the final diagram. With polaroid prints, care should be taken to ensure that the polaroid print size is suitable for the use intended.

The teacher then traces over the parts of the print desired for the diagram (Photograph 1). The photograph is then bleached (Photograph 2). Several formulations of photographic bleach are possible, but the one we use is:

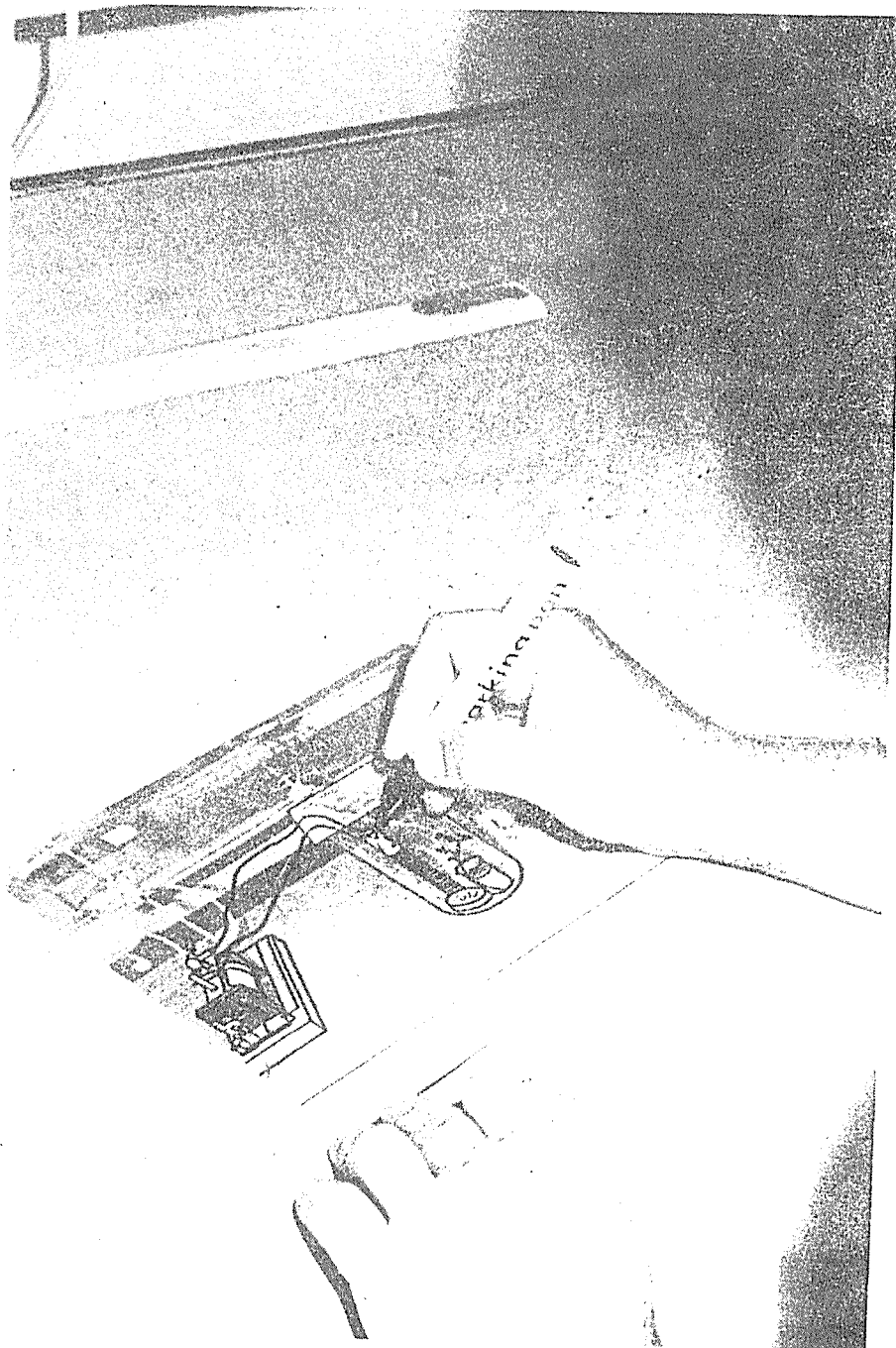
100g $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (lab grade), 100g Na Cl, 10mL conc. HCl, then water to 1L.

Dip the prints into the bleach until all the photograph disappears. The ink outline should remain. Several makes of felt-tipped pens produce a good result. Indian ink is not suitable since it tends to flake off.

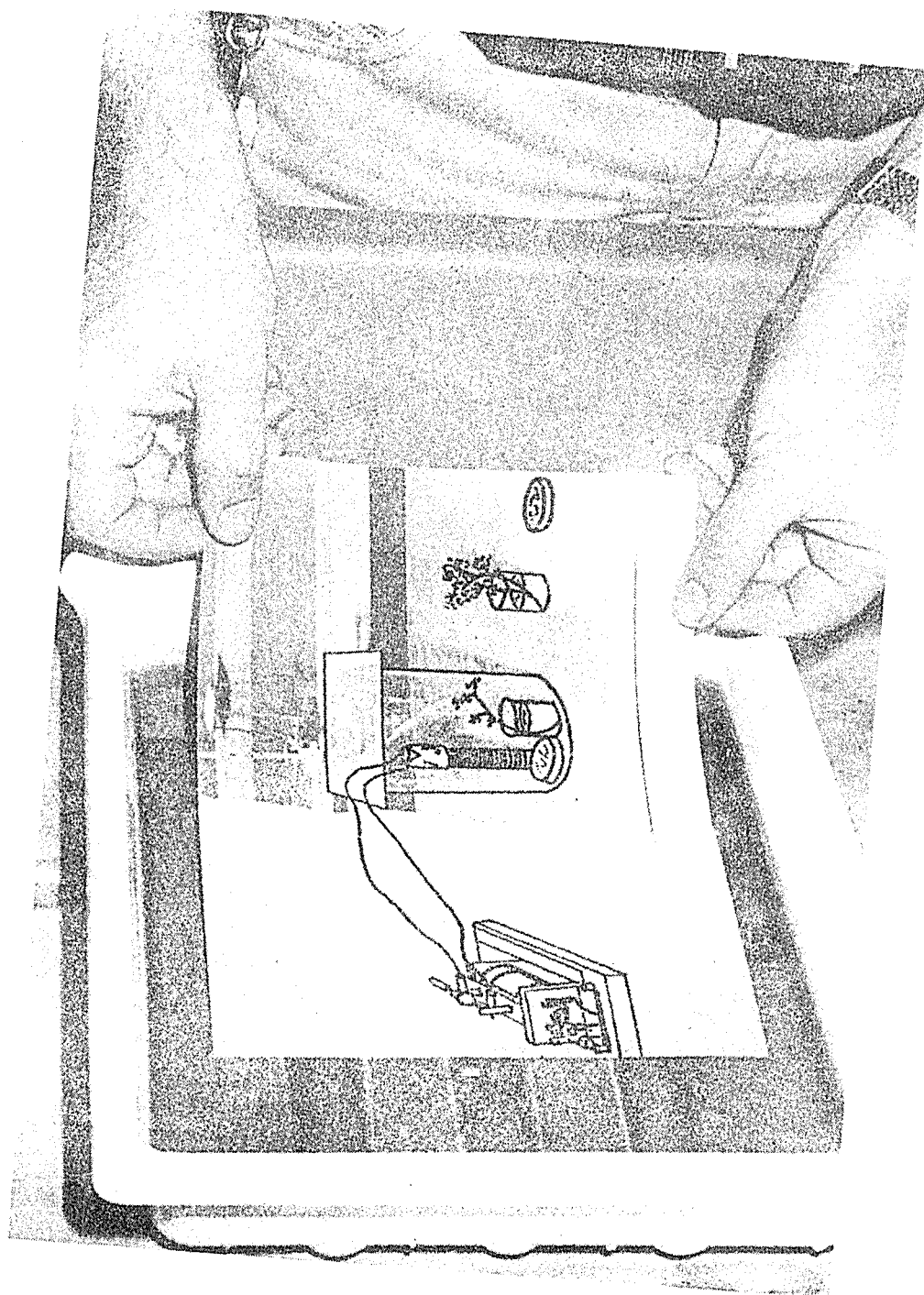
The print is then fixed again and dried. Prints treated in this way will photocopy very well; they can also be used to make thermal stencils and overhead projection transparencies.

The page shown was produced for a laboratory manual in a chemistry course at Mitchell CAE. the authors have also employed the method in producing a first draft of the Environmental Chemistry Module of the Academy of Science's High School Chemistry Project.

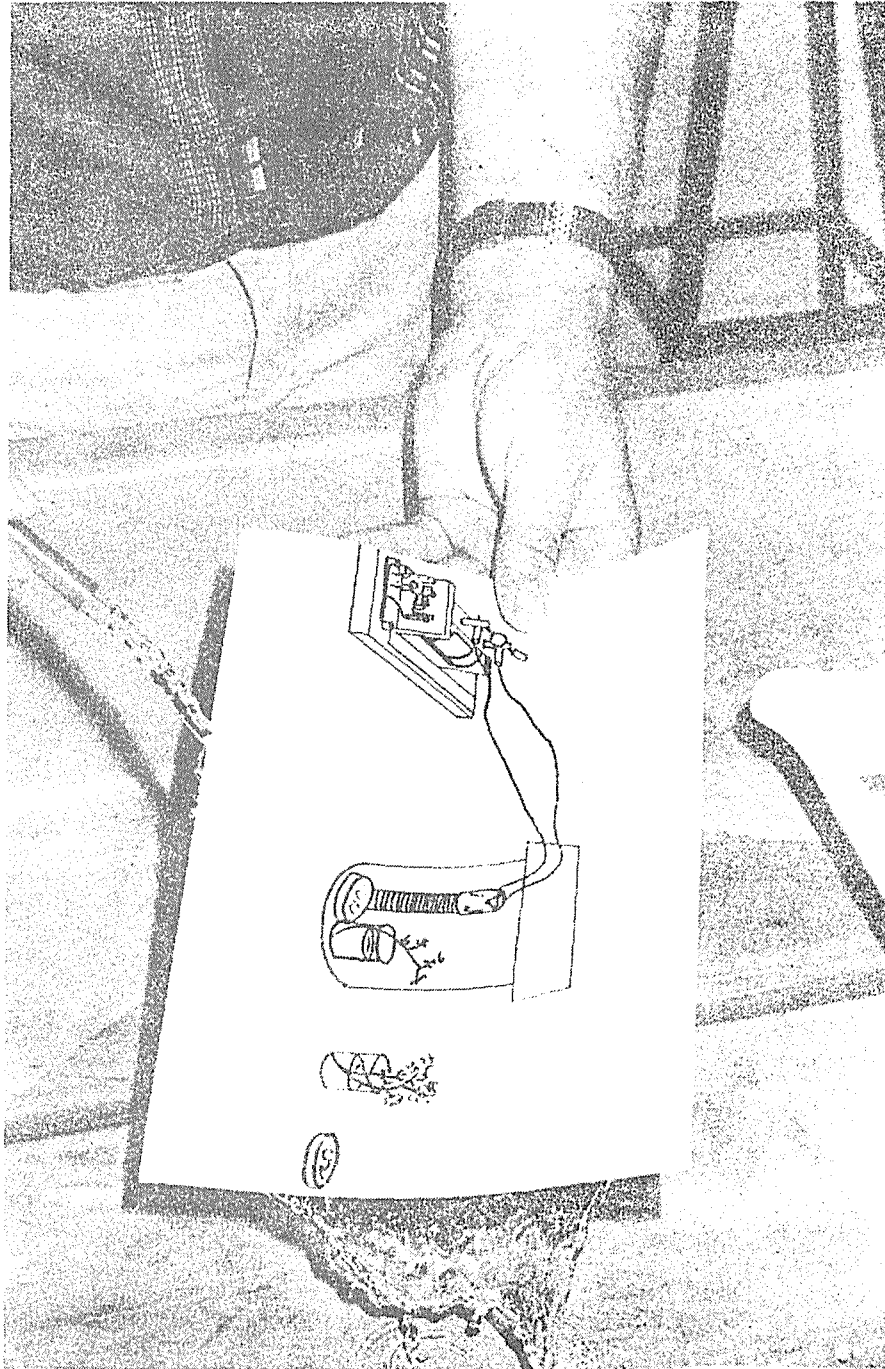
Some stages in the process



1. Going over the objects on the print.

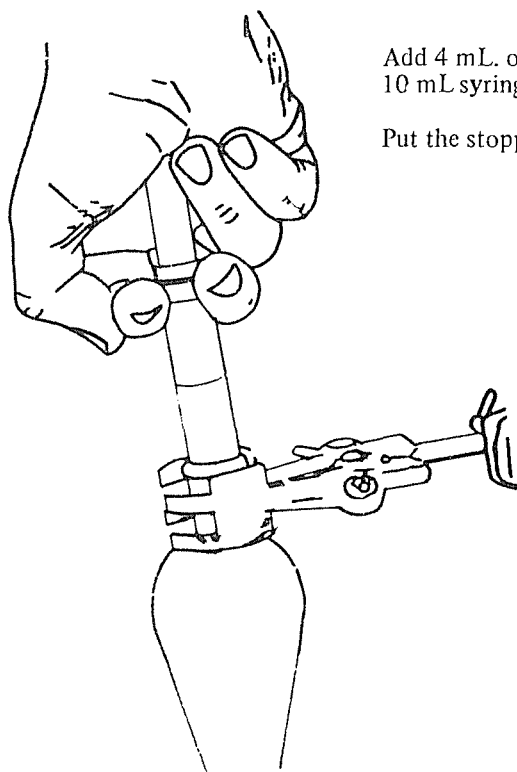


2. Bleaching the image.



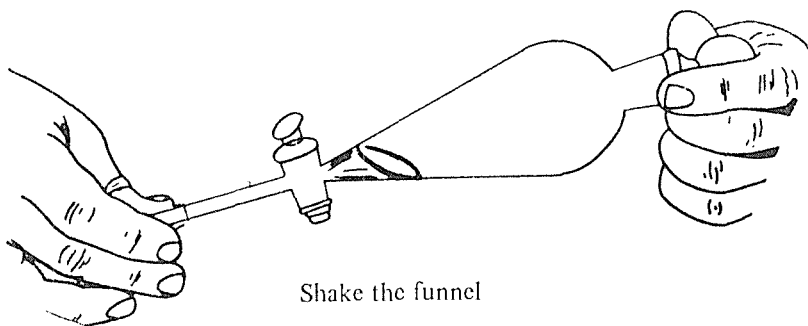
3. Washing

Analysis for Carbon Dioxide



Add 4 mL. of 60% KOH using the 10 mL syringe.

Put the stopper on quickly.



Shake the funnel

A.

Introduction

The first laser was built in 1960 by Theodore Maiman, a research scientist working for the Hughes Corporation. His research paved the way for the development of a fantastic array of fascinating devices and very useful tools. Today, lasers are used in surveying, geophysical measurements, medical applications, electronic component manufacture, atomic fusion research, precise distance measurement and a host of other applications.

1. What is a Laser?

A laser is simply a light source, but it has several differences from a normal light source.

- a) The light from a laser is pure or monochromatic light, occurring at a specific frequency (or frequencies).
- b) The light is coherent, that is, if light is considered as a bundle of waves, the laser light has all the waves in the bundle in phase where the crests of one wave coincide with the crests of every other wave in the bundle. This must follow from the fact that the light is monochromatic as only waves of the same frequency can be in phase all the time.

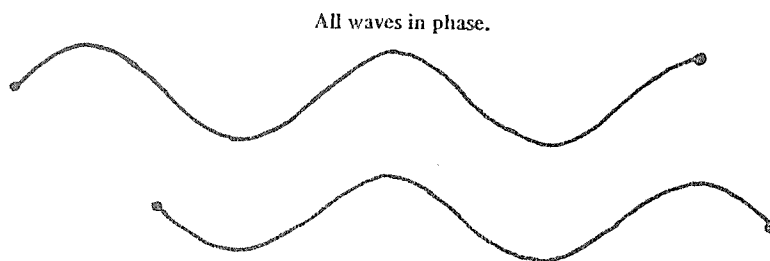


Figure 1.

- c) Laser light is highly directional. Only light on the axis between the mirrors of the laser device is allowed to escape. The beam which does emerge is narrow and well collimated. It diverges only a tiny amount rather than spreading as does the beam from a torch or spotlight. At 50 metres from the laser the beam is still less than 1cm in diameter.
- d) Laser light is extremely intense even from a small, low power laser.

A 1.0 milliwatt laser produces a beam with the same intensity as the sun.

2. How is Laser Light Produced?

Though the laser is a fairly recent scientific development the fundamental idea behind its operation has been with us since the early 1900s. The actual process of producing laser light involves theories from quantum theory, atomic physics and energy levels of orbital electrons.

There are many different types of laser devices available, however the helium-neon laser (usually available in schools) only will be discussed. This laser consists of a glass tube containing two metallic electrodes and a gas mixture of about 90% helium and 10% neon. The gases are confined under a pressure of about 1 to 3 kilopascals. The ends of the glass tube are precision machined and mirrored, one mirror being slightly transmissive and the other totally reflective.

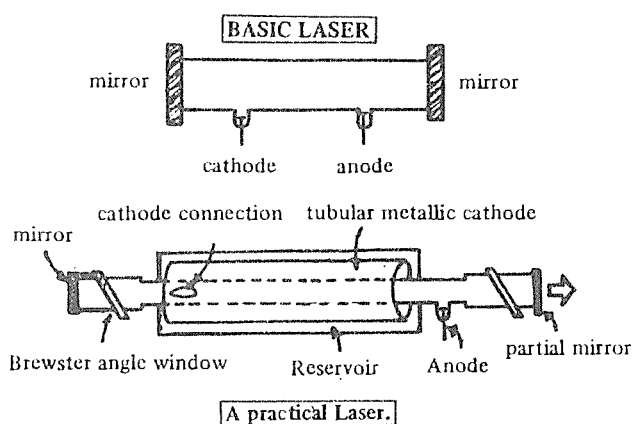


Diagram 2.

To start laser action within the tube a high voltage, in the order of 8 to 10 thousand volts, is applied to the electrodes. This causes a glow discharge within the gas mixture. At this stage electrons in the atoms of both gases jump from their ground state energy level to a higher energy level. When these electrons return to the ground state they emit light of a particular frequency, depending on the energy released by the electrons. There are two ways an electron can emit this energy;

- a) by **spontaneous emission** where the photons of light are emitted in all directions **randomly**.

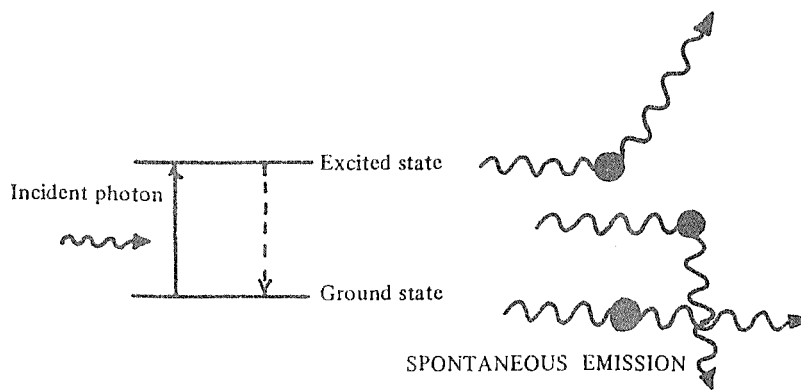


Diagram 3A.

- b) by **stimulated emission** where the excited electron is stimulated into releasing its energy by the interaction of a photon of light. In stimulated emission the energy of the incident photon and the energy released by the electron are the same, so two photons of light are produced which are in phase. This is **coherent** radiation.

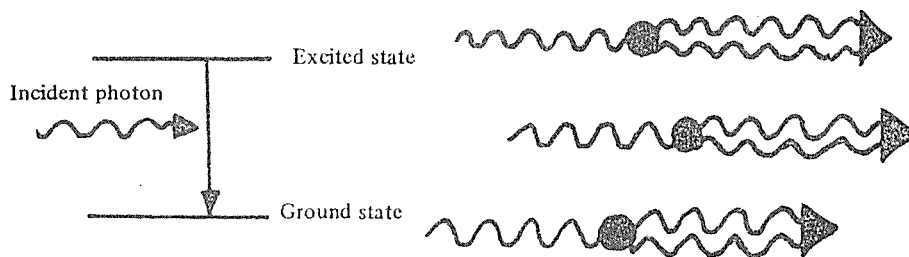
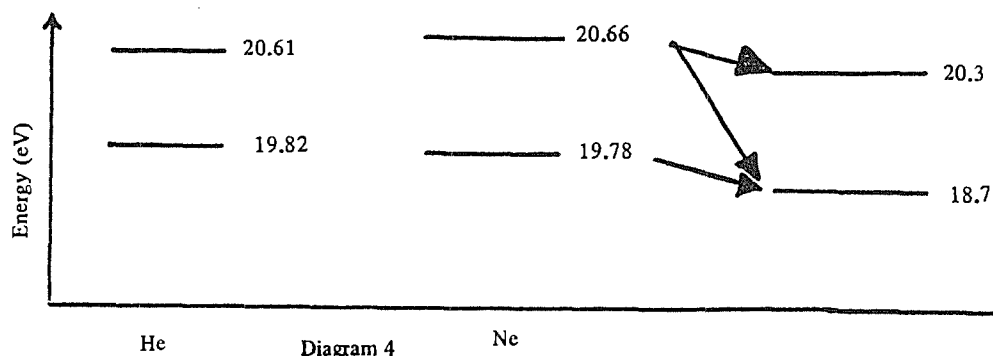


Diagram 3B

STIMULATED EMISSION

Normally only about one in 10^5 atoms is in the excited state of 1 000K, so very little coherent radiation is produced. It is essential for laser action to have a condition in which the number of excited atoms exceeds the number of atoms in the ground state. This is known as a population inversion. If this population inversion can be sustained then photon multiplication can occur.

Pumping, the process used to maintain the population inversion, is accomplished by the use of the helium gas. Two energy levels for helium coincide closely with two energy levels in neon. Energy transfer between excited helium atoms and ground state neon leads to large populations of excited neon atoms.



Excited electrons in the neon may drop to lower energy levels, as indicated in diagram 4, giving rise to three possible radiation frequencies:

- 20.66eV to 20.3eV (3391nm in the far infrared)
- 19.78eV to 18.7eV (1152nm in the infrared)
- 20.66eV to 18.7eV (632.8nm in the visible spectrum)

Any photons of the above wavelengths which are emitted parallel to the axis of the tube will be reflected back and forth between the two end mirrors and as each passes through the tube it gives rise to further identical photons by the process of stimulated emission. This leads to the name LASER, an acronym for Light Amplification by Stimulated Emission of Radiation.

Since one of the mirrors is slightly transmissive some of the coherent, monochromatic light can escape and this is the laser output. Of course each of the three wavelengths is produced. However, the mirrors are designed to attenuate the unwanted wavelengths and allow the wanted wavelength only to be transmitted, in this case 632.8nm.

3. Is a Laser Dangerous to Use?

Yes, it is dangerous, however, provided you observe some simple rules about its use, the danger is minimal.

- Respect all laser devices as they can cause serious damage. A 1 milliwatt output laser can damage the retina of the human eye.
- Never look directly down the laser beam or towards the laser part even if the device is not operating. A ping-pong ball provides a reasonably safe cover for an operating laser.
- Make sure that there are no reflecting surfaces (other than those being used in the experiment) in the area where the laser

is being used. A reflection to the eye is just as bad as the direct beam. Rings, watch bands, glass ware and taps are some examples of reflecting surfaces.

- d) Do not use a telescope or binoculars to observe a distant laser.
- e) Sun glasses are not sufficient protection even from a low power laser.
- f) Protect passers-by by covering all windows and placing signs on all entrances to the room where the laser is operating.
- g) Keep the room illumination as high as possible for the particular demonstration or experiment. This keeps the pupil of the eye small and minimises the risk of eye damage.
- h) Never leave an operating laser unattended.
- i) If the laser is being used outdoors do not track vehicles or aircraft with its beam.
- j) Do not operate a laser in rain, snow, fog or heavy dust as potentially dangerous, uncontrolled specular reflection can result.
- k) Beware of electrical hazards; the unit operates at about 2000V and contact may be lethal. Do **not** remove the cover and adjust the tube while you have power applied.

4. Does the Laser and Associated Equipment Need Special Storage?

Again a few simple rules will keep your laser in good condition for many years.

- a) Do not leave the laser on unnecessarily.
- b) Store the unit in a dust free area, as high voltages tend to attract large amounts of dust. A plastic cover would also help in this respect.
- c) To prevent corrosion make sure that the storage area is dry and free of chemical stocks.
- d) Keep all optical accessories clean and free of fingerprints. If necessary clean lenses and prisms after each use. Wrap the accessories in lens tissue and store in marked envelopes.
- e) Never use solvents to clean plastic optical materials.

5. Are There Any Restrictions on the Use of Lasers?

Yes, and it is most important that they are followed. They are for your, as well as the students', protection.

Lasers for school use must have special approval for use if they are not the requisition item. Those available on requisition will not need special approval, but they will be in the low power, continuous visible radiation category. No pulsed laser or laser operating in the infrared or ultraviolet regions of the spectrum or a laser with an output greater than 5 milliwatts will be approved

for use in schools. A member of the science staff at each school where a laser is used is to be designated as the 'laser safety officer'. This officer is to be in sole control of the operation, storage and maintenance of the laser.

The following references will provide further or more detailed information:

1. Electronics Today International, July 1980.
2. Science Notes, Nos. 4,16, 22 and 29.
3. St. George Science Bulletin, No.1, 1981.
4. Circular to Principals, Laser Safety, No. 76/23.
5. Electronics Australia, October 1977.

Note: Diagrams were reproduced and much of the information adapted from Electronics Today International, July 1980. This journal is under copyright. Permission for reproduction has been granted by Electronics Today International.

B. The Laser: Teacher Demonstrations

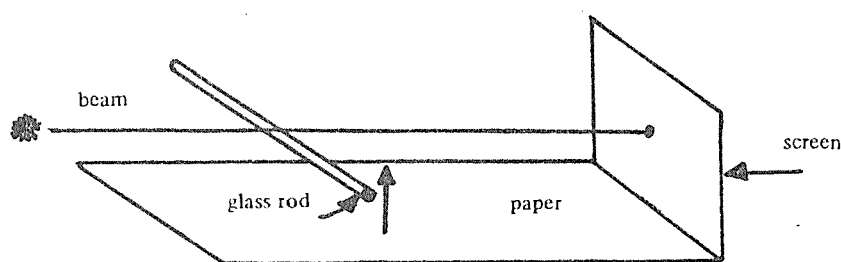
1. Beam intensity can be shown using a 25W opal lamp. About 5% of the 25W goes out as light (i.e. 11/4W). Distributed over the surface of a globe 60mm in diameter gives about 1 400W/m² flux. The laser's spot can be seen on the glass showing that the intensity is as great as that of the sun.
2. Monochromaticity may be demonstrated using either a prism or a grating. In neither case is there any appreciable dispersion of light.
3. Divergence is observed by holding graph paper in the beam at various distances from the laser port. The laser's beam diverges much more slowly than light from conventional sources. It is said to be well collimated.
4. Polarisation is also evident in the beam. Rotating a polaroid sheet can extinguish the beam, revealing its near total polarisation.
5. Communication using a laser beam requires a fairly fast photodetector such as a photo transistor. To modulate, vary the discharge current slightly and the intensity of output will vary too. It's just another amplitude modulated signal. (See appendix for a working circuit.)
6. Total Internal Reflection: Dust and air movements prevent long distance communications in air but total internal reflection can be used for near lossless guiding along fibres. Even a stream of water in air will guide light if its path is straight enough.
7. Scattering of coherent light by a finely irregular surface gives rise to a speckled interference pattern over the lit area. No two observers see the same pattern. It is sharp on the retina

irrespective of the eye's focal length because it is an interference phenomenon.

C. The Laser: Student Practicals

1. Producing a Divergent Beam

A divergent beam is so useful that it is the first tool introduced. The usual beam is so narrow that it is difficult to find. A strong lens is needed to produce a significant effect. A piece of 3 or 4mm diameter glass rod is used as a lens to diverge the beam. To observe its effect, place a screen 1/4m in front of the laser and a piece of paper on the bench at its foot as shown below.



Holding the rod horizontally, raise it slowly into the beam and then lower it again.

What is the effect of the lens?

What danger is associated with taking the rod right through the beam?

Set two more screens (or paper sheets) on either side of the beam. Describe the effect of moving the rod across the beam while held vertically or at some other angle.

How could you find the actual shape of the beam?

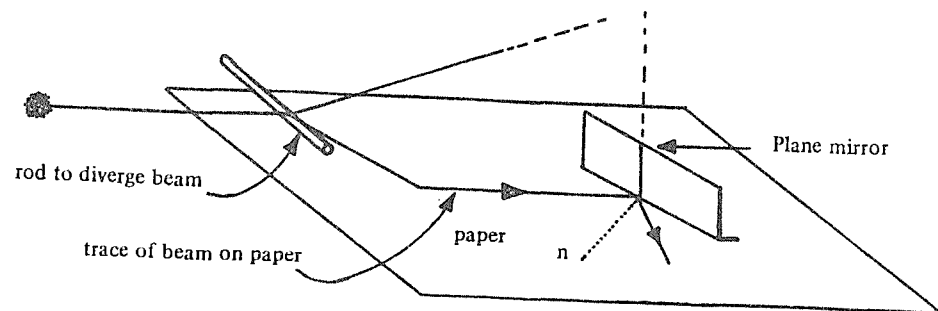
N.B. This type of beam will be used in later experiments. When used, set the lens up on a stand, close to the laser source.

2. The Law of Reflection

In this experiment you should become familiar with the divergent beam while verifying $\theta_i = \theta_r$. The exercise can be done in two ways:

- showing angles directly with a protractor under the mirror;
(see diagram below)
- by plotting ray paths and mirror positions on paper and checking the angles later.

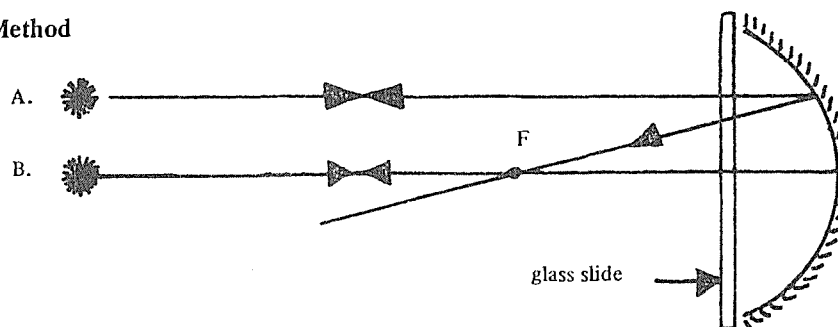
N.B. Do not forget to place the screens.



3. Radius of Curvature

This experiment will allow you to determine the focal length of a shallow cylindrical lens.

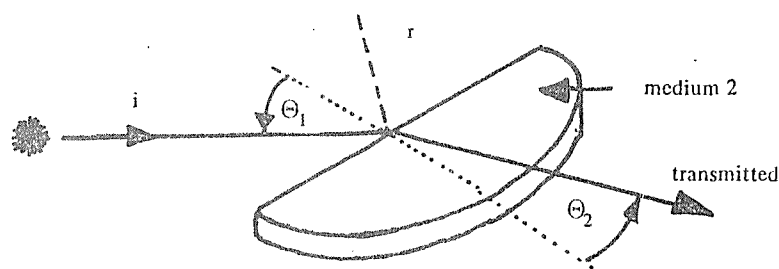
Method



The reflection from the glass slide will ensure that the beam is perpendicular and thus the lens is correctly positioned. Move the laser from A to B and plot the paths of the laser in order to measure the focal length.

4. Refractive Index of Perspex and Glass

The refractive index N_{12} tells us the relationship between the angles of incidence and transmission at the interface between media in which light travels at differing speeds. It may be found from the ratio of sines of the respective angles, i.e. $N_{12} = \sin \theta_1 / \sin \theta_2$.



We often speak of the 'refractive index' of glass, perspex, etc. In these cases the other 'medium' implied is a vacuum. Fortunately for us the velocities of light in vacuo and in air are so similar we can neglect the difference and carry on as if we lived in vacuo!

Finding the Refractive Index

Set up the laser and cylindrical lens to produce the dispersed beam. Allow the beam to follow a sheet of paper on the bench. Place the semi-circular prism so that the light strikes the centre of its straight side.

(How can you check this?) There will now be three rays on your paper. Mark and label them i for incident ray, r for reflected ray and t for transmitted ray. Vary the angle of incidence and find the corresponding angle of reflection.

5. Critical Angle

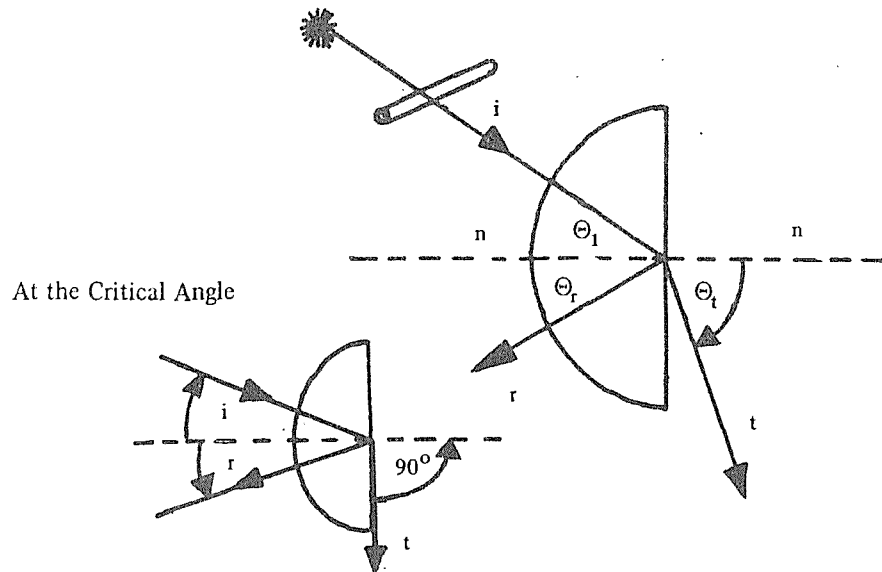
As might be imagined there is a limit on how far one can bend a beam of light as it passes from a medium of higher refractive index to one of lower refractive index. There is an angle θ_i for which θ_t is 90° and no light is transmitted. This value of θ_i is called the critical angle (θ_{crit}).

For angles of incidence greater than θ_{crit} there is total (internal) reflection of the incident light.

Method

Use the divergent beam again. Lay the perspex D-prism on a sheet of paper in the path of the laser beam, with the curved face nearest the laser. Adjust the prism so that the i-ray is normal to the curved surface and then rotate the prism gently until the t-ray is just extinguished. Mark the paths of i and r. You can use $\theta_i - \theta_r$ (to avoid having to find the normal). This gives us:

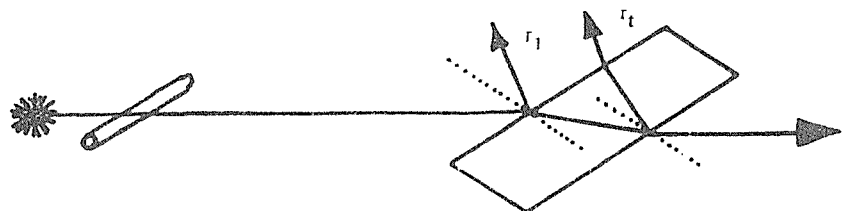
$$\theta_{\text{crit}} = \frac{\theta_i + \theta_r}{2}$$



6. Two Methods of Beam Splitting

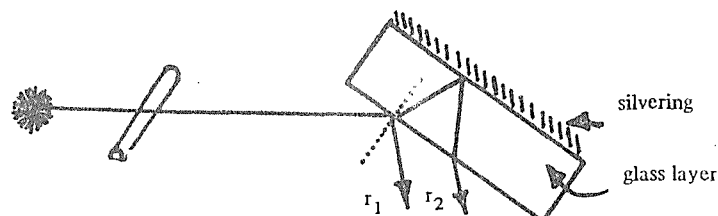
At any interface there is bound to be some light reflected. With the intense light of a laser this may be of use or a potential hazard.

Set up the laser with its cylinder lens so that a streak appears across a sheet of paper. Place a piece of glass in the beam so that the incident, transmitted and reflected rays may be observed as it is rotated.



Try various thicknesses of glass, using a piece of tape to block off r_2 and various angles of incidence. Compare the intensities of r_1 , r_2 and t .

Another non-specialised beam splitter is the second-surface mirror (the kind we use every day).



How do the reflected rays behave as the mirror is rotated?

Are they equally intense? Parallel?

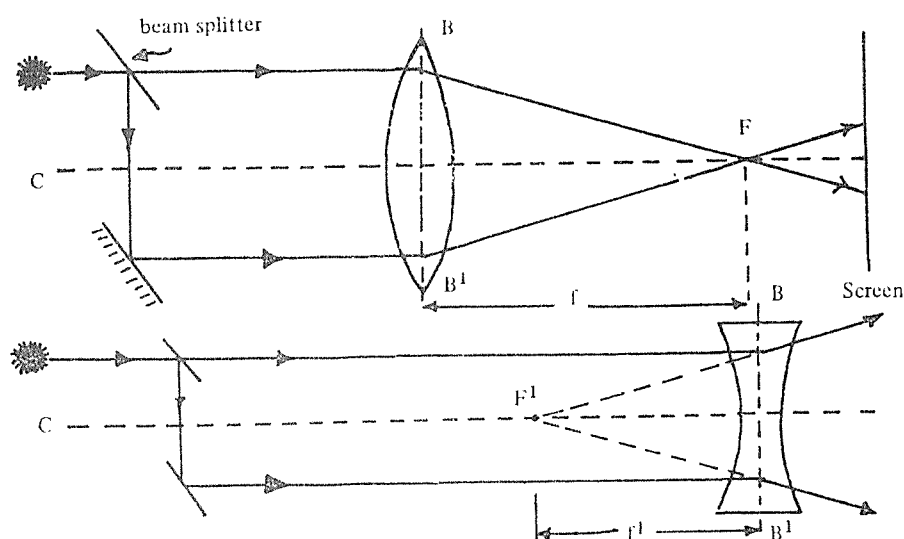
Does it compare favourably with the first type?

Can the beam separation be changed easily?

7. Finding the Focal Length Using a Split Beam

This is one of the classical ways of finding the focal length of a lens and hence its power (or diopetre): $p = 1/f$. Being monochromatic, chromatic aberrations are undetectable, but asphericity is quite easy to detect.

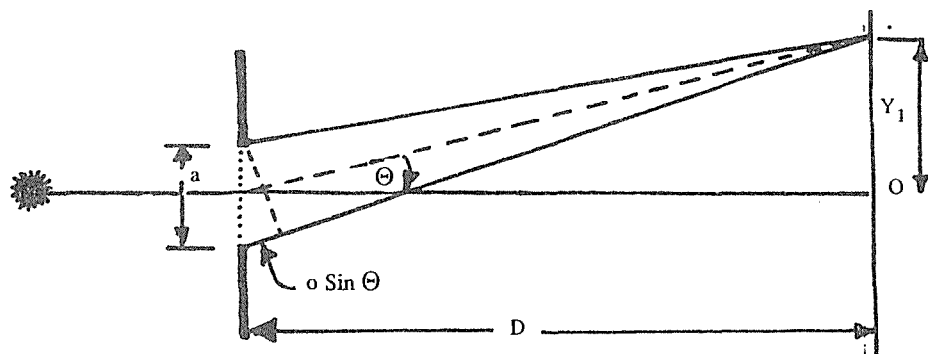
Set up the laser, beamsplitter and mirror to give parallel rays equidistant from a line on a sheet of paper. Set your lens up so that its axis is on the centre line, 'C'.



Apart from the safety screens a small moveable screen is needed for exploring the beam paths. With the convex lens, F may be found directly, but F' must be deduced for the concave lens. In both cases the plane BB' (at which the incident and transmitted rays intersect) must be deduced from ray plotting before the focal length is found and the power calculated.

8. Measuring the Wavelength of Light - Single Slit

Following Huygens' idea of infinitesimal radiators of circular wave fronts, the criterion for having a maximum intensity at a point, Y , is that there is an integer number of wavelengths' path length difference between Y and the two edges of the slit.



Given a slit ' a ' metres wide, D metres from the screen, with $D > a$ and n an integer, then for Y to have a bright spot:

$$a \sin \theta = n\lambda$$

For $n = 0$ the spot lies at O . This is the transmitted or zero order maximum. The first bright spot caused by diffraction is at Y_1 such that;

$$\lambda = a \sin \theta_1$$

Therefore $\lambda = a Y_1/D$.

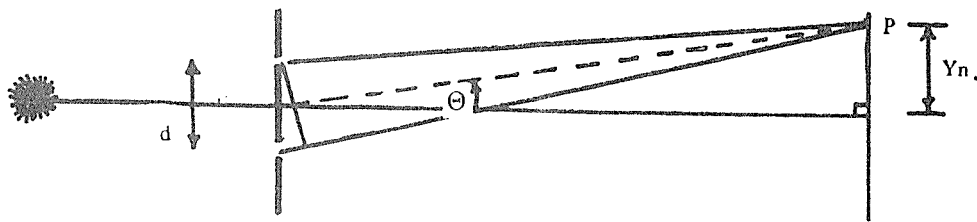
The next, at Y_2 has $2\lambda = a Y_2/D$, etc.

Since D , Y_1, Y_2 , etc. can be measured this provides a way of finding λ providing ' a ' is known (or a way of finding ' a ' if λ is known)

The laser, slit and a screen may be set up as in the diagram to allow the wavelength of the laser's light to be measured.

9. Measuring the Wavelength of Light - Double Slit

For infinitesimally wide slits and a normally incident wavefront, where the slits are d metres apart, λ is the wavelength and P lies at an angle of θ from the normal to the plane of the slits.



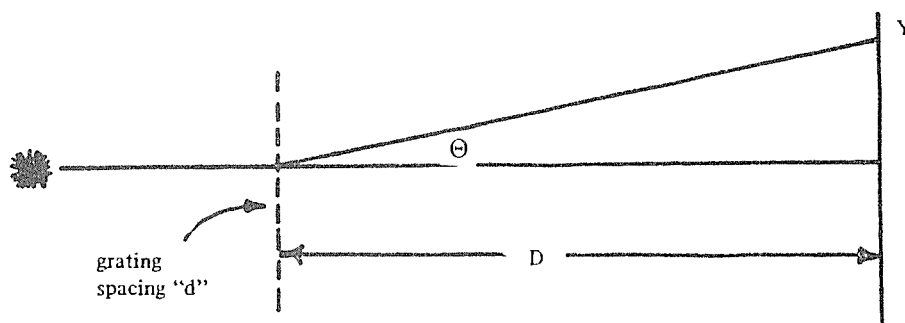
For constructive interference (a bright spot at P) then $n\lambda = d \sin \theta$ where $n = 1, 2, 3$ etc. If P is Y_n metres from the normal and the screen is at D ($> d$) metres from the slits we can substitute for $\sin \theta$ to get

$$n\lambda = \frac{dY_n}{D}$$

Choose a double slit and attempt to measure λ .

10. Measuring λ Using a Diffraction Grating

Once again the criterion for constructive interference is that there is a whole number of wavelengths difference in path length from consecutive slits to the screen, i.e. $d \sin \theta = n\lambda$.



With 'd' very small ($\approx 10\mu\text{m}$), this makes for quite large angles θ so the positions Y_n of maxima at the screen are readily measured. (The grating also passes a lot of light. Three laboratory walls can be used in demonstrations)

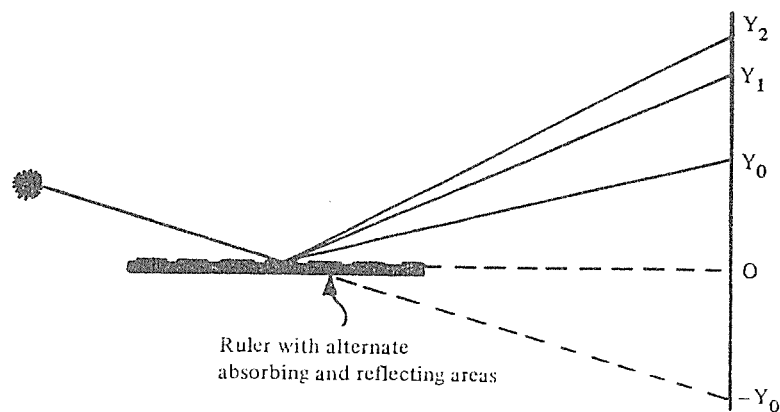
How many orders can you see when the grating, laser and screen are judiciously set up?

Displaying the paths of diffracted rays: pass the diverged beam through the grating and project the beams onto a table.

11. Measuring the Wavelength of Light Using a Steel Ruler

Yes, this has been done. It was first reported in Am. J. Phys. Vol. 33 (Nov. '65) by A.L. Schawlow.

The set up is as simple as in the diagram.



First locate Y_0 with the ruler absent, then move in the ruler so the beam strikes near its end. Y_0 is the position of the specular reflection.

Y_1 is the first maximum, Y_2 is the second.

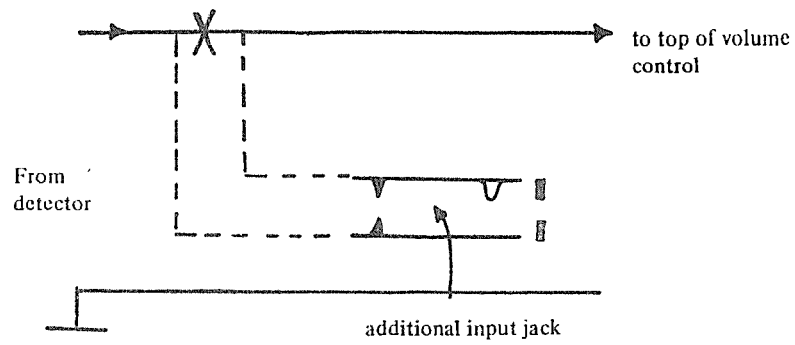
Analysis is complicated by having an angle of incidence, making analysis messy. Schawlow's result is reported as:

$$\lambda = \frac{d}{2n} \frac{Y_n^2 - Y_0^2}{D^2}$$

where d is ruling spacing
 n is the order
 D is the distance, about 2m from ruler to screen
 Y_0, Y_n are measured from 0 which is midway between $-Y_0$ and Y_0 .

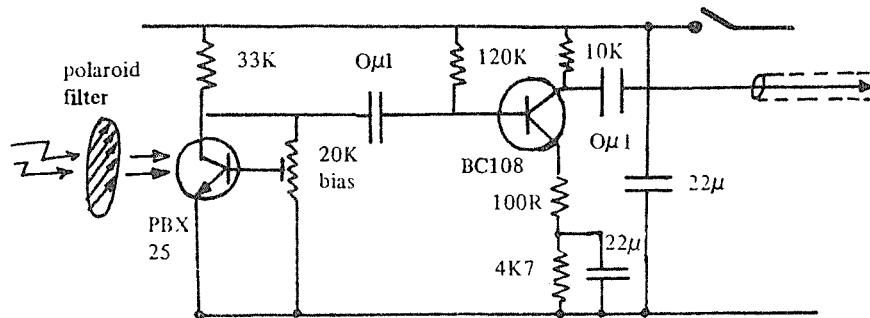
12. Modification of a 'Tranny' for Use as an Amplifier

The easiest way of doing this is to locate the 'top' or clockwise end of the volume control, unsolder its connection, then add in the leads to the new jack. The commonline goes to the bottom of the control. Insulate both well.



13. Photo Transistor and Preamplifier

The polaroid filter may be used to prevent saturation of the transistor when a polarised beam is used (e.g. with a laser).



MULTI-LEVEL PRACTICAL TEST FOR AN ELECTRIC CIRCUITS UNIT, USING A 'BLACK BOX' MAZE (SEN 1982, Vol. 31 No. 4)

Brian Shadwick, Assessment and Evaluation Unit

The apparatus for this practical test has been adapted from similar apparatus used by Robin Gooley, Goulburn HS. Rob has designed a series of 'black box' circuits for use in a Behaviour Unit. In his application, Year 12 students record the number of errors made by Year 7 students as they trace out the live circuit over repeated trials. In this way, the experiment resembles the rat in a maze situation, but allows much more complexity in maze design, including numerous dead-ends.

I have taken the basic idea and adapted it for testing various skills associated with current electricity. Each piece of apparatus can be used to test one simple skill or a string of skills of varying complexity.

Some of the activities a student might be asked to carry out are indicated on the following pages.

The Apparatus

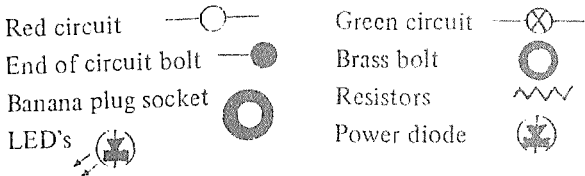
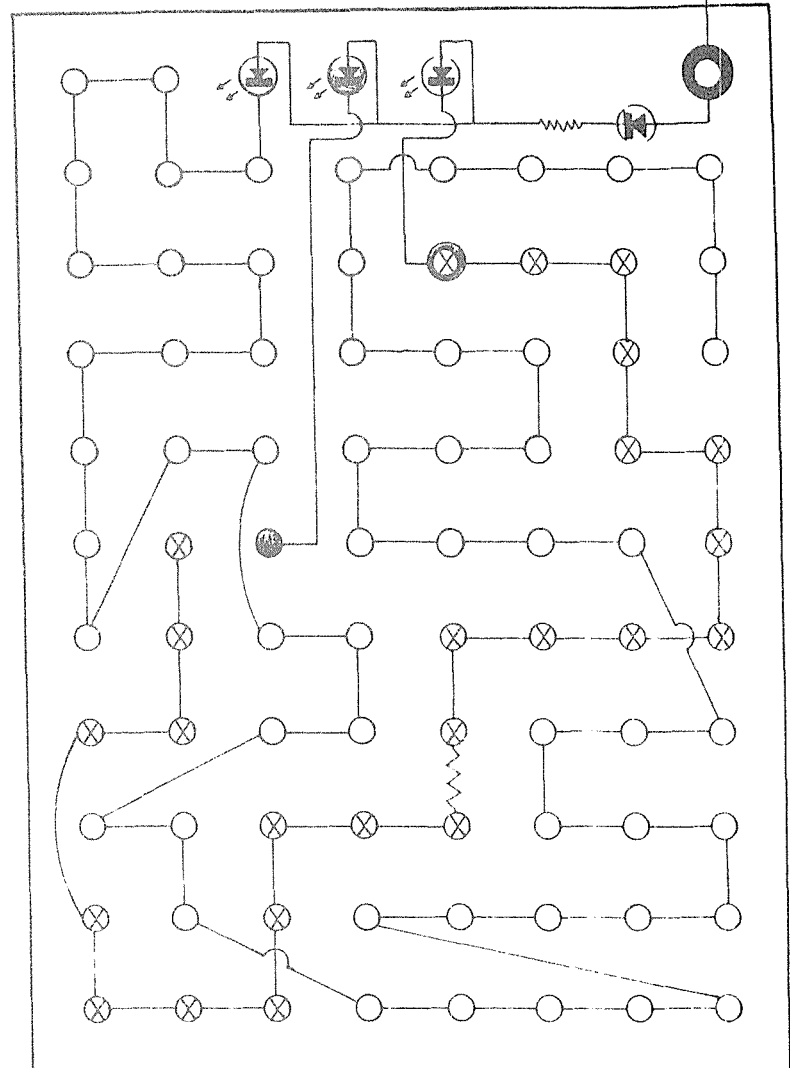
To construct the apparatus, the following materials were used:

- a) 2 pieces of peg-board, 8 holes x 11 holes
- b) 1 x 560ohm resistor (to protect LEDs)
- c) 1 x 560ohm resistor (as unknown component)
- d) 1 x green TIL220R LED (to indicate green circuit)
- e) 1 x red TIL220R LED (to indicate incorrect path)
- f) 1 x yellow TIL220R LED (to indicate end of circuit)
- g) 1 x IN4001 diode (to protect LEDs against a large incorrect polarity in student use)
- h) 1 x banana plug socket
- i) about 75 x 1.25cm steel nuts and bolts
- j) 1 brass nut and bolt (starting point for probing)
- k) wire

Approximate cost in Sydney: \$2.70.

Sample Circuit

probe ← Power pack



Steps in Construction

1. Cut out 2 pieces of peg-board; paint if you wish.
2. Screw nuts and bolts into top board.
3. Wire green circuit under nuts; include unknown component and brass nut and bolt.
4. Wire incorrect circuit to remaining nuts. (Insulate all crossings.)
5. Connect banana socket, 560ohm resistor, power diode and LEDs to each other as shown in circuit diagram.
6. Connect green circuit to green LED. (Watch polarity.)
7. Connect incorrect circuit to red LED.
8. Connect brass nut to yellow LED.
9. Lay base board over ends of bolts and screw nuts on. Use longer bolts on corners so that the maze bolts will not stick through the holes in the base board.
10. Test circuit. (Use 4 - 6V.)
11. Correct any faults, or make modifications.
12. Write student activity/test cards.

Statistics for Circuit Shown

A. Green Circuit - banana plug to brass bolt

For setting G on power pack:

$$\begin{aligned}V &= 13\text{V} \\I &= 10\text{mA} \\R &= 1.3\text{k}\Omega\end{aligned}$$

B. Green Circuit - brass bolt to last green bolt

For setting G on power pack:

$$I = 24.5\text{mA}$$

$$\begin{aligned}V &= 13\text{V} \\R &= 530\Omega\end{aligned}$$

C. Red Circuit - banana plug to any red bolt

For setting G on power pack:

$$\begin{aligned}V &= 13\text{V} \\I &= 20\text{mA} \\R &= 650\Omega\end{aligned}$$

Using the Apparatus (to trace the green circuit)

1. Connect the positive terminal (red) of the transformer power pack to the banana plug on the peg board.
2. Connect a probe to the negative terminal of the power pack.
3. Turn the power pack to setting G.
4. Start with the probe on the brass screw - the green LED should light up.
5. Moving ORTHOGONALLY ONLY, (left, right, up or down), NOT diagonally, trace the path of the green circuit (green LED).
6. Mark the green circuit on the answer template provided, by colouring in the bolt tops green.
7. If the red LED comes on, you have gone the wrong way. Backtrack to your previous bolt and try another direction.
8. The yellow LED indicates that you have reached the end of the green circuit. Colour this bolt yellow on the answer template.
9. Draw the circuit on the template by connecting the green bolt tops, from the last green bolt.

Option A

1. Use the meters provided to measure the current flowing in the green circuit.
2. Use the meters provided to measure the current flowing in the red circuit.
3. Account for the difference in these currents, if any.

Option B

1. Use the meters provided to measure the resistance of the green circuit.
Make your measurement between the brass bolt and the last green bolt.
2. Show all calculations.

Option C

A circuit component is hidden somewhere in the green circuit.

- Find where the component is.
- Identify what it is.
- Calculate its value, if any.
- Complete your green circuit diagram by adding the symbol for this component in its correct position on the template.

Option D

Use the apparatus provided to determine the position and value of any resistance in the red circuit.

Option E

- Use the apparatus provided to determine the potential difference between the brass bolt and each other bolt in the green circuit.
- Tabulate these values.
- Graph potential difference against bolt number (i.e. bolt 1, bolt 2, 3, 4, etc.)
- Explain your results.

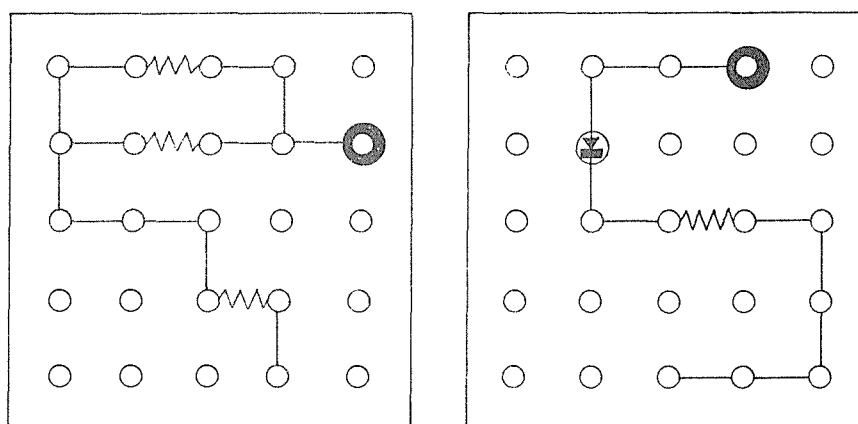
Option F

The circuit which connects the banana plug socket and the coloured LEDs to the bolts is hidden between the pegboard layer. Design and draw a circuit which would cause the LEDs to work in the way they have.

Further Applications

Obviously 'black boxes' like this can be used in a teaching situation as well as in practical tests. It also has applications in electronics as well as simple circuits.

The 'black boxes' can also be much more simple. Consider, for example, the pieces drawn below.



These consist of two pieces of pegboard, each piece 5 holes x 5 holes. Hidden between the pegboard, as before, might be various arrangements of 3 resistors. The following worksheet might be used.

A. The 'black box' contains several resistors in a circuit.

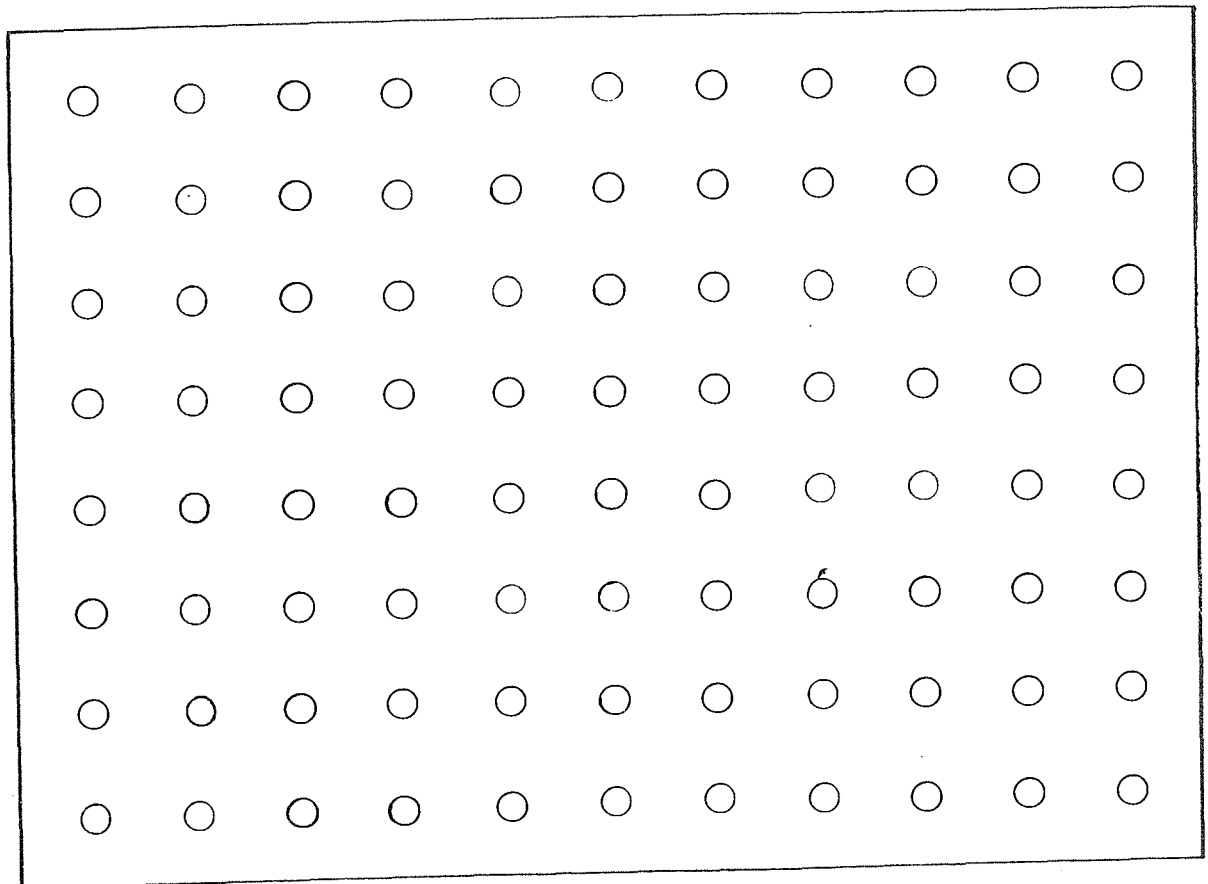
1. Trace the circuit.
2. How many resistors are in the hidden circuit?
3. What are their values?
4. How are they connected, in series or parallel?
5. Draw the circuit on the template provided.

Alternatively, students could be given the following.

B. The apparatus contains two hidden components.

1. Trace the circuit.
2. Find the positions of the hidden components.
3. Identify each component.
4. Determine its value, if relevant.
5. Draw the circuit on the template provided.

Electric Circuits "Black Box" Answer Template.



HOW STRONG IS PAPER? (SEN 1982, Vol. 31 No. 4.)
From 'The Science Teacher', March 1982.

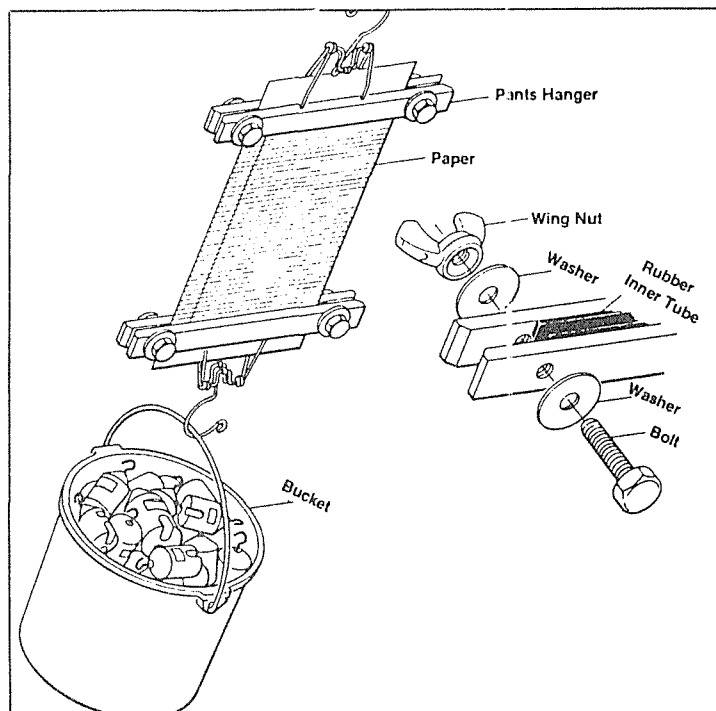
Suspend a bucket over a demonstration table with a sheet of paper clamped between two modified pants hangers. (See diagram.) Slowly and carefully add weights, or objects of known mass, to the bucket.

Ask the class, "Who can predict the breaking point of the paper?" Continue to add weights until the bucket is nearly full. It is hoped that students, impressed by the considerable tensile strength of paper, will carry on the test themselves to discover the breaking force.

A dramatic conclusion to the demonstration is to paint a thin line of water across the face of the paper. Most paper under tension, will separate along the water line in a few seconds. Depending on the height of suspension, the crash can be resounding.

Additional Questions which could be asked are:

1. Are two sheets of paper twice as strong as one sheet?
2. Are all types of paper equally strong?



MEASURING MAGNETIC FIELDS USING A HALL EFFECT DEVICE (SEN 1983, Vol. 32 No. 1)

John Pearce, Chemistry and Physics Department, Melbourne State University

Introduction

Measuring static electric fields has always been a difficult task, particularly in school laboratories. The usual procedure is to measure the deflection of a small compass from magnetic north and after a vector calculation, arrive at a figure showing the relative strength of the field compared to that of the earth. This technique has two points in its favour:

- i) the actual technique of comparing two perpendicular vector quantities to obtain relative values is worthy of investigation
- ii) the '10 cent' compass is indeed a very sensitive (albeit crude) instrument for indicating field directions (the earth's magnetic field strength is approximately 5×10^{-5} tesla or gauss).

This article describes a device for measuring magnetic fields directly and with reasonable accuracy. Its principle of operation is the well known Hall Effect enabling detection of magnetic fields as low as 5×10^{-4} T.

Background

If a material (metal or semiconductor) carrying a current I is placed in a transverse magnetic field B , then a magnetic force F_m will act on the current carriers in a direction perpendicular to both I and B (see Figure 1).

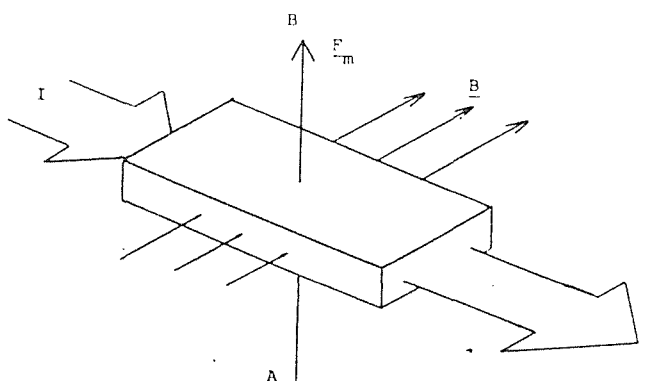


Figure 1

This effect was discovered by E.H. Hall in 1879. The direction of the force is independent of the sign of the charge carriers, hence measuring the resultant induced voltage (V_{AB}) not only indicates the strength of the magnetic field, but also the sign of the charge carriers. (It is this property of the Hall Effect that enables us to verify that semiconductors can conduct using negative carriers (electrons) or positive carriers (holes) and that the holes act like classical free positive charge carriers.)

Hall Effect devices are found in a variety of applications such as computer terminal keyboards, car ignition systems, speed sensors, proximity sensors, magnetic field detectors, etc.

For our purpose, however, we are interested in a measurement of the Hall Effect voltage, which is proportional to the magnetic field strength that is to be determined.

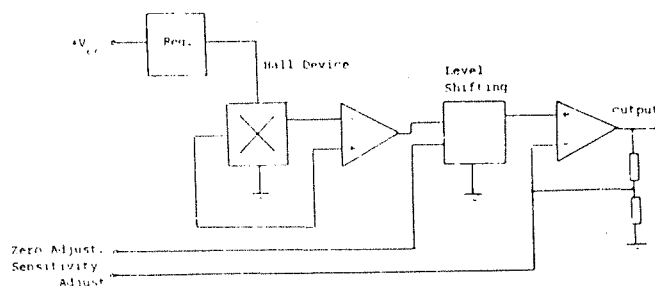


Figure 2.

An Integrated Hall Effect Circuit With Analogue Output

a) Siemens Device SAS231

This is an integrated circuit which incorporates a Hall sensor plus an analogue output amplifier (see Figure 2). The IC contains all the circuitry necessary to output a voltage proportional to an applied magnetic field. However, a few external components are usually required to give control over sensitivity and zero setting. A level shifting circuit is incorporated, enabling an external voltage to determine the output voltage when the field is zero. The IC also contains an operational amplifier whose gain can be altered externally, enabling the sensitivity of the device to be varied.

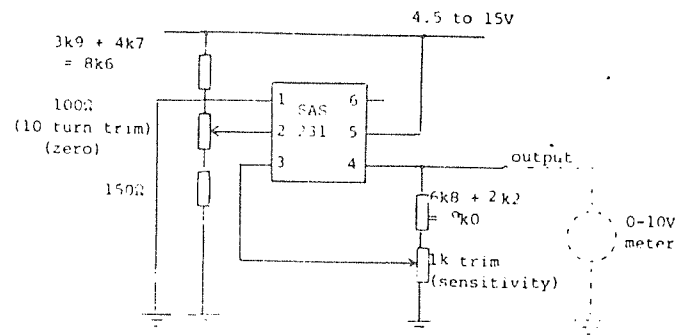


Figure 3

b) Implementing a Circuit to Measure Magnetic Field

Figure 3 shows a complete circuit designed to use the device to measure magnetic fields of the strength typically found around small magnets.

Since the magnetic field must be applied to the IC itself, it is preferable to mount the IC on a small piece of 'veroboard' attached to the end of a probe. The leads from the IC can be terminated on another piece of 'veroboard' holding the four resistors (see photo 1).

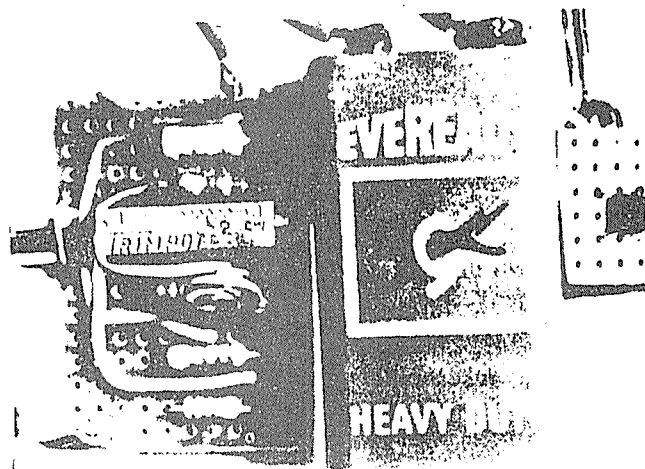


Photo 1

Due to the sensitive nature of the circuit, one of the two potentiometers employed needs to be a '10 turn trim pot' (i.e. 10 turns of the adjustment screw moves the wiper from one extreme

to the other, thus allowing fine adjustments of 'zero'). For normal use, one would set the sensitivity to a convenient setting, then adjust the 'zero' to one half of the supply voltage while no external field is applied. This allows magnetic fields of either sense to be measured. Note, however, that adjusting the sensitivity will affect the zero setting.

c) Calibration

Without calibration, the circuit can be used to compare relative magnetic field strengths. Any change in the output voltage is proportional to the applied magnetic field. The output voltage will saturate at about two volts below the supply voltage.

Calibrating the circuit is simple and a good exercise for students in itself. A PSSC 690 turn air-core solenoid can be used.

Applications

Being able to directly measure field strength opens up many interesting areas of investigation.

Unfortunately, the circuit is not sensitive enough to detect the field around a single current carrying wire. Even with a current of 10amps, the field at 1cm is about 0.2mT. This corresponds to a deflection of less than 0.2volts from the zero and would become lost in the drift of the signal. (It makes one appreciate how sensitive those '10 cent' compasses really are!)

An obvious area where such a device can be used is in plotting the magnetic field around a magnet or coil. An added advantage here is that students can actually obtain a numerical value for the field a magnet produces at a given distance. How many students currently could say whether a 'typical' bar magnet produces a field of 10^4T , 1T or 10^{-4}T at one of its poles?

Alternating fields can be observed with the aid of an oscilloscope. This has application in electromagnetic induction, 'leakage' from a transformer, etc., used to provide a uniform, predictable field given by the expression:

$$B = \mu_0 n I$$

where μ_0 = magnetic permeability of free space

n = number of turns per unit length

and I = current.

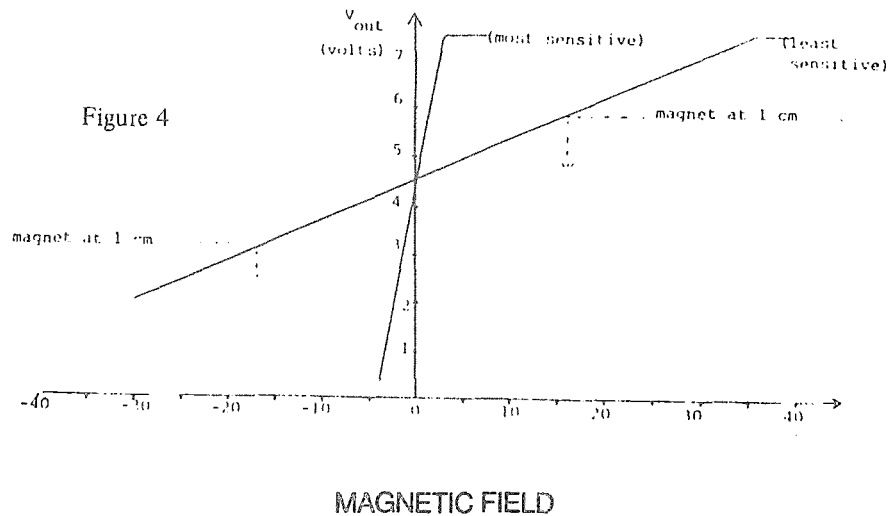
Substituting the values:

we get $\mu_0 = 4\pi \times 10^{-7} \text{ Tm A}^{-1}$

$n = 690/0.149 \text{ m}^{-1}$

and $B/I = 5.8 \times 10^{-3} \text{ T A}^{-1}$

Calibrating graphs for the device set at each extreme of sensitivity are shown in Figure 4.



Shown on one of the graphs is the response to a typical school bar magnet held 1cm from the probe. (Approx. 0.02 T or 220 Gauss).

The sensitivity ranges from about

70mV/mT to 930mV/mT

(0.40mV/mA) (5.4mV/mA)

(The air core solenoid will carry up to 7amps for short times.)

Conclusion

For about \$8.00 and an hour or so of time, a device can be made to extend students' ability to probe the physical world. The simplicity of the circuit and relatively low cost makes it a useful alternative method for measuring magnetic fields.

References

U. Lachmann, SAS 231, An Integrated Hall Effect Circuit with Analogue Output, Components Report XIV (1979) No. 6 SAS 231 available from: Systems Reliability Australia Pty. Ltd., (Syncom) 49 Tope Street, South Melbourne. 699 8433.

OBSERVING THE SUN (SEN 1983, Vol. 32 No. 2)

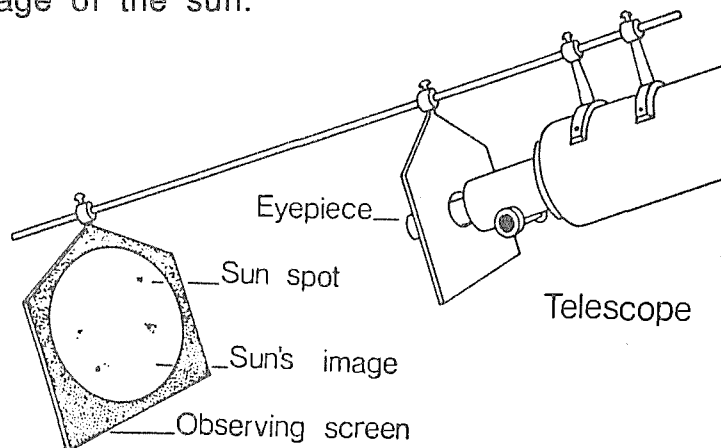
Jeff Ryder, Curator, Brisbane Planetarium

Watching the sun is a fun astronomy project that students can try during school hours. All that is needed is a small telescope and a smooth white card. If your school or the school board science consultant cannot come up with a telescope ask your students. Small astronomical telescopes are becoming quite common.

Caution: The eye can be blinded or injured by a direct look at the sun with a telescope. Warn your students never to look directly at the sun with or without a telescope. The sun-filters sold with many small telescopes are unsafe. Besides only one person at a time can look.

The safe, simple way to observe the sun is to use the telescope to project its image onto a white card as shown in the diagram. Many fancy gizmos are sold to hold a projection card in place on the telescope, but hand holding it or taping it to a chair works fine.

Point the telescope towards the sun by watching its shadow. When it casts a perfectly round shadow it is pointed correctly. Then hold the card about a foot behind the telescope's eyepiece. A little fine tuning with the focusing knobs and some minor adjustments in pointing the telescope should turn the bright fuzzy blob on the card into a crisp image of the sun. Try poking a hole in a piece of cardboard and placing it over the telescope tube to cast a pool of shade around the projected image of the sun.



This diagram shows one simple set-up for projecting the sun's image. Some telescopes use a mirror or a prism to project the image off to one side, rather than directly behind the eyepiece as shown here. If your telescope has a small finder, cap it or cover the lens with cardboard and tape before pointing the telescope at the sun.

Reprinted from STAQ Newsletter, No. 9, December 1982

**ADDITIONAL EXPERIMENT ON POLARISATION OF LIGHT FOR
ELECTIVE 2 - WAVE NATURE OF LIGHT (SEN 1983, Vol. 32 No. 2)**
Alan Smith, Tempe HS

Some of the available resources, Fundamentals of Physics and PSSC, do not have a practical suitable to demonstrate the relationship $I = I_0 \cos^2 \theta$ listed in the syllabus as being suitable for mathematical treatment.

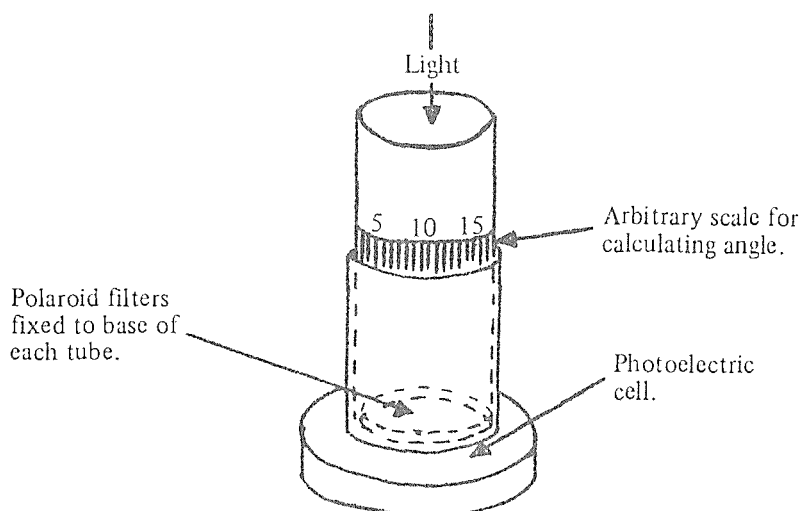
This demonstration can be made from materials in the PSSC optical kit, or, if need be from sunglass lenses and cardboard tubing. The following demonstration has been used successfully with Year 12 students.

Aim: To show that light passing through two polarising filters placed at

an angle θ to one another is given by:

$$I = I_0 \cos^2 \theta \quad \text{where} \quad I_0 = \text{incident intensity} \\ \text{and} \quad I = \text{resultant intensity}$$

Method: Two polaroid filters were fixed into tubes which were then placed onto a photoelectric cell of a 'Lux' meter, as shown in the diagram.



An arbitrary scale was attached to the inside tube (Graph Paper) which had a total of 77 divisions to cover 360° .

$$\begin{aligned} \text{THUS:} \quad 1 \text{ Division} &= \frac{1}{77} \times 360^\circ \\ &= 4.67^\circ \end{aligned}$$

STEP 1: Find the position so that the light intensity is a maximum, i.e. polaroids are parallel.

An arbitrary scale was attached to the inside of the tube (graph paper) which had a total of 77 divisions to cover 360° .

$$\begin{aligned}\text{Thus 1 division} &= \frac{1}{77} \times 360^\circ \\ &= 4.67^\circ\end{aligned}$$

Step 1 Find the position so that the light intensity is a maximum, i.e. polaroids are parallel.

Step 2 Adjust illumination to maximise scale deflection.

Step 3 Record division number and light intensity, then repeat at regular intervals for at least 90° .

Angle and Intensity Sample Result

'POSITION' 'LUX'	ANGLE		RADIATION INTENSITY 'ANGLE IN
	'ANGLE IN DIVISIONS'	DEGREES'	
56.5	0	0	490
60.0	3.5	16.4	440
62.5	6.0	28.0	380
65.0	8.5	39.7	280
67.5	11.0	51.4	180
70.0	13.5	63.1	90
72.5	16.0	74.8	25
75.0	18.5	86.5	5
77.0	21.5	100.5	15

CALCULATIONS

To show that $I = I_0 \cos^2 \theta$ we could:

- plot I v. $\cos^2 \theta$ since I_0 is constant
- calculate $I_0 = \frac{I}{\cos^2 \theta}$ I should be a constant for all values of I and θ
- calculate some other constant such as $K = \frac{I_0 \cos^2 \theta}{I}$

We shall use $I_0 = \frac{I}{\cos^2 \theta}$

TABLE OF CALCULATED VALUES

ANGLE θ (deg)	$\cos^2\theta$	I	$I_0 = I/\cos^2\theta$
0	1	490	490
16.4	0.92	440	478
28.0	0.78	380	487
39.7	0.59	280	472
51.4	0.39	180	462
63.1	0.20	90	440
74.8	0.07	25	364
86.5	3.7×10^{-3}	5	1341
100.5	0.03	15	452

All of the calculations for I_0 in column 4 should have the same value. Why would you expect angles approaching 90° to produce greater variations (errors)?

Conclusion: These results indicate that the calculated values of I_0 are within reasonable agreement with I_0 at 90° . Thus we may state: $I = I_0 \cos^2\theta$

You should now perform a similar experiment with refinements such as:

- * fix the external tube in position (use clamp)
- * correct I value by subtracting background radiation at given angle
- * change intensity so more accurate values are taken as θ approaches 90° (difficult).

Questions

1. Rewrite this demonstration fully as an experiment, showing Aim, Method, etc., showing the theory of light which is applicable to polarisation and how $I = I_0 \cos^2\theta$ is arrived at and an appreciation for the errors involved in any calculations. (You need not take multiple readings.)
2. How would you check that the photoelectric cell has a linear relation to intensity of the incident light?

Editor's Note

For those with a 'spread sheet calculator' program like 'visicalc' the entire result and calculation table would be relatively easy to program.

USING A LASER AND PLASTIC FIBRES TO TRANSMIT SPEECH

(SEN 1983, Vol. 32 No. 4)

Karl Becker and Benildus Ng, Christian Brothers' College, Sutherland

Introduction

Few science teachers, or students, will be unaware of the recent advances in using optical fibres for telecommunications. The basic principle of fibre optics, internal reflection of light, is easily understood and just as easily demonstrated, using traditional optics kits. The 1 milliwatt helium-neon lasers, now available to school science departments, make possible an exciting demonstration of the way lasers can be used to transmit speech through glass or plastic fibres.

While the focus of attention in the demonstration outlined below is on the use made of fibre optics for telecommunications and thus pertinent to a topic such as Communications, there are many facets of the demonstration to which the focus could be shifted if required. For example, the focus could be on diffraction for a Year 11 or 12 Physics class dealing with the Wave Properties of Light, or yet again on the photosensitive transistor and amplification for a Year 11 or 12 Physics class dealing with the Electronics elective. Depending on the focus of attention, various aspects of the working apparatus can be treated as 'black boxes' so as not to distract students from the point being demonstrated.

Background and General Procedure

Figure 1 below shows the general outline of the equipment required for the demonstration.

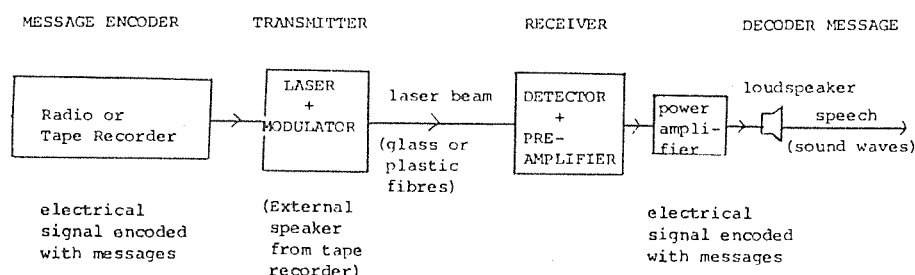


Figure 1: A laser communication system

Message Encoder (Tape Recorder)

We have found it simplest to use a radio or tape recorder connected to an external speaker. If the teacher wishes to have students' voices transmitted 'live', then it is understood that the voice signal should be amplified before applying it to the speaker.

Transmitter (Laser plus Modulator)

Modulation is performed mechanically by a pinhole moving across a fixed laser beam. This, of course, is a relatively crude way of modulating the laser beam, but one which is easily performed, easily understood and can actually be seen by students. Figure 2 shows the modulator. It consists simply of a small piece of copper sheet (about 2 x 1cm) glued to the centre of a small speaker. The laser is directed at a pinhole in the copper sheet. As the speaker cone vibrates up and down according to the pressure variations of the (electrical) voice signal there will be a corresponding shifting of the whole diffraction pattern of the beam emerging from the pinhole. If the central maximum has initially been directed onto the plastic fibre(s) and hence to the light sensitive transistor, then the shifting of the diffraction pattern will result in a variation of the intensity of the light received by the phototransistor in accordance with the voice.

Actually, the edge of the copper sheet rather than the pinhole can be used to modulate the laser's intensity. Though the quality of sound produced is not so good, this method does eliminate the need for any discussion of diffraction with junior classes.

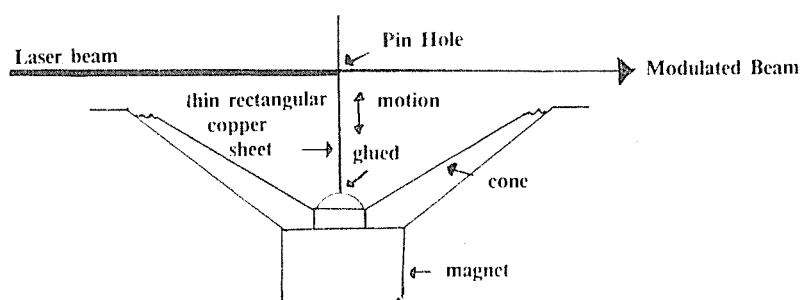


Figure 2: Pin Hole Modulator

Channel (plastic fibres)

These can be used singly or in bundles. Obviously, the demonstration is a more forceful one if the fibres are coiled or bent, as this is their advantage. They are easily and cheaply obtainable from electronic stores. If thin glass tubing is substituted, a length not more than 20cm is recommended as the glass absorbs too much light. It is possible, of course, to do the whole demonstration without the fibres. In this case the channel is air and the demonstration can be one of radiowave modulation and transmission. Indeed, the whole apparatus can be set up firstly without the fibres and these inserted later.

Receiver (Detector and Preamplifier)

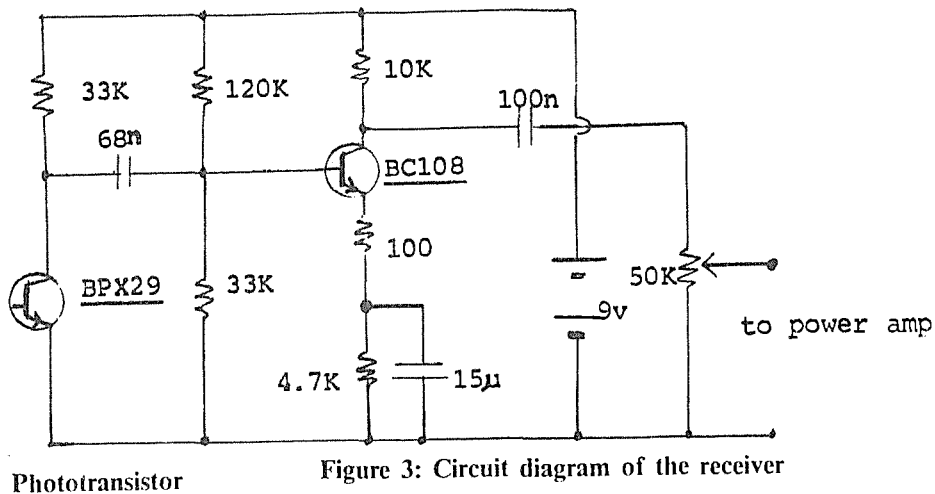
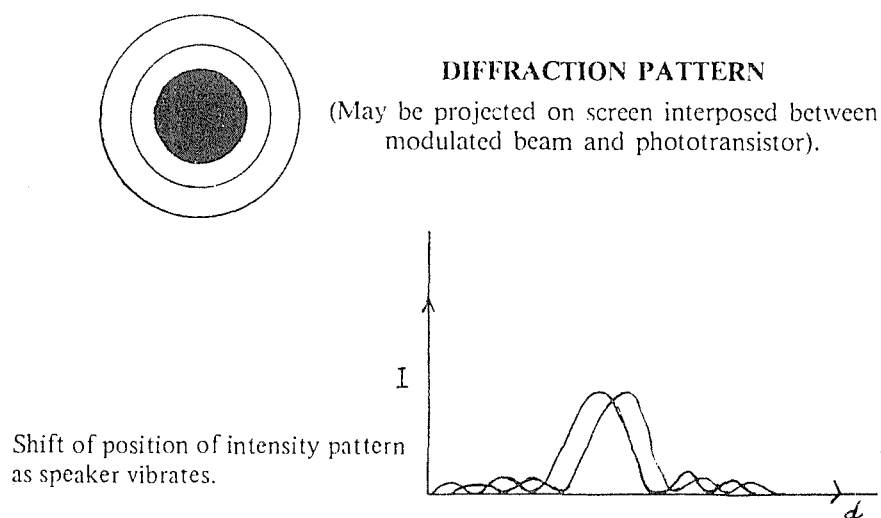


Figure 3 shows the circuit diagram for the detector and preamplifier. This, of course, has to be made prior to the demonstration. Electronics buffs - and every school has them - love making such modules! It is suggested that this module be covered with cardboard with a hole for the laser to strike the photo transistor. This is to avoid stray laser reflections off exposed metals during the setting up. When monochromatic light strikes a photo transistor it produces an output current proportional to the intensity of the incident light. Thus, as the central maximum of the diffraction pattern shifts position according to the pressure variations of the speaker carrying the modulator, so the intensity of light striking the photo transistor will be similarly modulated. (c.f. Figure 4.) The output current is then amplified by the second transistor.



Decoder Message.

Any suitable amplifier can be used. The one used with the Microwave Kit is ideal as it has the speaker and amplifier in one unit. The sound received is quite a reasonable reproduction. Clarity can be improved by fine adjustments of:

- a) the laser light striking the photo transistor
- b) the variable resistor in the receiver circuit
- c) the volume control of the radio or tape recorder used

The range of frequencies which are detected can be checked by substituting an audio-oscillator for the radio and a CRO for the decoder speaker. A frequency range of 300 to 3kHz is quite reasonable for essentially distorted sound reproduction.

General Notes

1. This demonstration is not intended just for teachers who are electronics or laser buffs. Detailed knowledge of electronic circuitry is not required. The usual safety precautions are to be taken, of course, when using the laser.
2. Each sub-unit can be tested independently of the other part before putting them all together.
3. The smaller the pinhole used, the larger the diffraction pattern. This increases the modulation received. If transmission is through air this diffraction pattern also determines the range of transmission, but with fibres the range is not affected by altering the pinhole size.
4. Two problems which thinking students commonly raise regarding the use of fibres involve:
 - i) loss of intensity if fibres are very long
 - ii) interference effects as different paths are followed by different light rays in a single fibre

Technology already has answers to these problems. Optical fibres can now be made so that they absorb the same amount of light in 150 metres that would be absorbed by a centimetre of window pane glass.

The ingenious solution to the second problem was to make fibres in such a way that the refractive index decreased from the centre outwards. A rate of variation can be chosen so that a zig-zagging ray arrives at the same time as a ray travelling straight through the centre.

Conclusion

Provided the sub-units are pretested, this demonstration is one which is relatively foolproof as well as being as exciting one for teachers and students alike. The sub-units, once made, can be stored and the experiment repeated indefinitely with relatively little time consuming preparation for each demonstration.

References

Student Projects in Physical Sciences, Vol. 6, University of NSW, 1982.

The Promise of Optical Communications, Brochure issued by Telecom Australia, September, 1979.

THE MICROWAVE KIT AND LASER (SEN 1983, Vol. 32 No. 4)
Kevin Molyneux, Cabramatta HS

A What are microwaves?

The term microwave stems from the fact that these electromagnetic waves have a wavelength of about 10^{-6} (or micro) of the wavelength of radio waves. Thus, with a wavelength of about a few centimetres, microwaves lie between radio waves and infra-red radiation on the electromagnetic spectrum and overlap these two to some extent.

B. What does the kit consist of?

For a cost of \$250 on the 1984 requisition, you get a transmitter, a horn detector, two large metal plates, one small metal plate, a large solid wax lens, a lens holder, a large solid wax prism, a polarising grill and a large plastic plate.

You must supply 2 power packs and an audioamplifier.

C. What can you do with the kit?

You can demonstrate almost any wave phenomenon you like with it. Usually, the major problem is setting the kit up and keeping it in working order. (So what's new?)

1. Setting up the equipment

- * Connect the transmitter to the power pack. (12V AC)
- * Connect the receiver to the audioamplifier.
(N.B. Most Important. Do NOT connect the receiver directly to the power pack. This is a major cause of breakdown of the kit.)
- * Connect the audioamplifier to the power pack.
- * Place the transmitter and receiver about 1 metre apart and switch on; if everything is alright you should be able to control the sound at the audioamplifier.

2. Penetration of different materials, e.g. metal plates, plastic, wax.
3. Reflection, e.g. around a barrier using the metal plate as a mirror.
4. Refraction, e.g. through the wax lens.
5. Total internal reflection, through the wax prism.
6. Diffraction, through the slit formed by the two metal plates.
7. Interference, through the two slits formed by the two large metal plates and the smaller metal plate between them.
8. Polarisation, using the grills vertically and horizontally, or turning the receiver through 90° .

D. Where in science programs could the kit be used?

Obviously in senior Physics the kit finds the greatest application in showing the wave phenomena of electromagnetic radiation and can be used as an alternative, an addition, or a prelude to wave properties of light.

However, it is my contention that it can also find use in the junior course. For example, the kit might find use in the main content area Number 3, in the section on Obtaining and Using Energy. The kit could be used to demonstrate the idea of transmitter and receiver in radio; it could be used to show differences between sound and radio waves; and it could supplement studies of light to show similar properties for radio waves.

E. References

Not many of these are around, but perhaps the best is 'Fundamentals of Senior Physics' by Parham R. and Webber B., Lab. Manual No. 2, published by Heinemann, 1972. Experiment 5.12.

The Laser

A. Points to note before buying or using the laser

- * The laser, an acronym derived from Light Amplification by Stimulated Emission of Radiation, will cost you \$328 on the 1984 requisition.
- * Your school must appoint a Laser Safety officer (usually the Science Head Teacher or a Physics teacher) who must supervise its use and be satisfied that anyone using it knows how to use it safely.
- * Laser light can cause blindness by retinal burning. Thus it is vital that nobody looks directly into the tube or a reflection from a mirror or bright surface.
- * Doors must be locked and safety signs displayed when the laser is in operation.

B. What can you do with the laser?

As with the micro-wave kit, one can demonstrate many phenomena similar to light and thus find use for it in senior Physics.

However, I contend that it can also find use in the junior course in much of the same content areas as the microwave kit.

- * Seeing the beam; scatter chalk dust along the beam.
- * Reflection; use a plain mirror or more than one and again scatter chalk dust.
- * Refraction; pass the beam through a large beaker of water.
- * Total internal reflection; use the same beaker of water.
- * Scattering the beam; use a clear piece of ice.

- * Other experiments; these could include the laws of reflection, using a prism to show the monochromatic nature of laser light; determining the critical angle for water/air interface, etc. Once you start using the laser it is surprising how many experiments you can devise yourself.

C. References

1. For safety practices and regulations for schools, refer first to the Memorandum to schools dated 26th September 1983 on 'Safe Use of Lasers in Schools'.
2. The above memorandum replaces 76/23 on the 'Use of Lasers in Schools'.
3. Information can also be obtained from Science Notes Numbers 23 and 29.
4. A useful little booklet from Metropolitan South West Region is called 'Information on the Use of Lasers in Schools'.
5. Scientific American, August 1980.
6. 'Lasers', SEN, 1982, Vol. 31, No. 1. This is a most useful and comprehensive treatment of the use of the laser.

CIRCULAR MOTION ON AN INCLINED TRACK (SEN 1983, Vol. 32 No. 4)

Alan Smith, Tempe HS

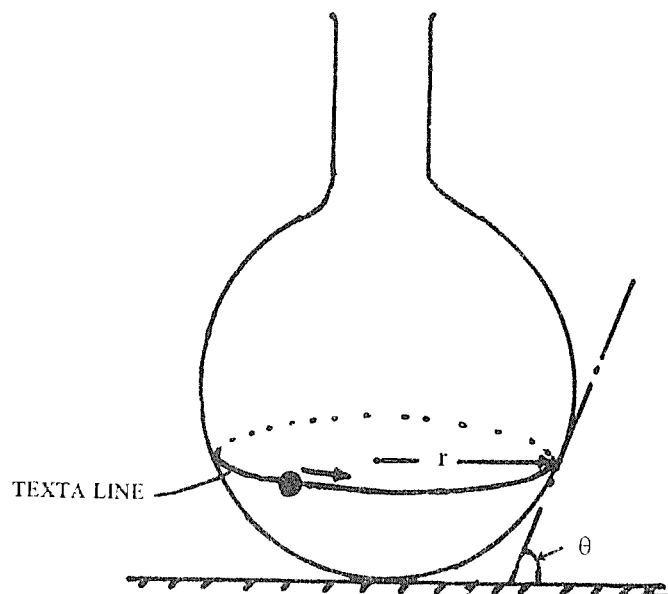
Here is a simple method of treating motion in a circle on an inclined plane. If care is taken with small round bottomed flasks (up to 500mL), results to within 5% of the expected value can be achieved by students. A 1 litre round bottomed flask works very well indeed.

Aim: To verify that the derived equation for subjects travelling about an inclined track obey the relationship:

$$\tan \theta = \frac{v^2}{gr} - (1)$$

Method:

1. Take a large round bottomed flask and draw a circle about its base (using texta). (See diagram below.)
2. Place a small ball bearing in the flask and start it rotating along the line drawn on the flask.
3. Time an appropriate number of revolutions of the ball bearing to calculate the period T.
4. Measure the tangential angle of the texta line with the horizontal.



Sample Calculations

The following measurements were taken in class.

$$\theta = 68^\circ$$

$$r = 5\text{cm}$$

$$\text{time for 10 revolutions} = 3.73\text{secs}$$

Calculate velocity V , using equation 1 and from the period of revolution.

$$\text{a) } \tan \theta = \frac{v^2}{gr}$$

$$\begin{aligned}\therefore v^2 &= gr \tan \theta \\ &= 9.8 \times 5 \times 10^{-2} \tan 68^\circ \\ &= 0.67 \text{ ms}^{-1}\end{aligned}$$

$$\text{b) } \text{Period } T = \frac{3.73}{10} = 0.3735$$

$$\begin{aligned}v &= \frac{s}{t} = \frac{2\pi r}{T} \\ &= \frac{2\pi \times 5 \times 10^{-2}}{0.373} \\ &= 0.85 \text{ ms}^{-1}\end{aligned}$$

A TWO SLIT INTERFERENCE EXPERIMENT (SEN 1984, Vol. 33 No. 1)

Colin Gauld, School of Education, University of NSW

When two patches of light combine on a screen to give areas of darkness the advantage of a wave model of light over the classical particle model is clearly demonstrated. The easiest way to show this to a class is to use a laser but a simple two slit interference experiment allows students to handle the equipment and to measure the wavelength of the light for themselves.

There are two versions of this experiment. In the most commonly described (and most easily carried out) form, the student looks through the two slits towards the light source and sees a pattern of dark and light bands of differing widths and intensities (Ref 1). However the nature of the pattern is not immediately obvious. The bands appear to be located somewhere near to the light source rather than on the screen and it may not be clear to the student that the normal explanation for the two slit interference applies in this case.

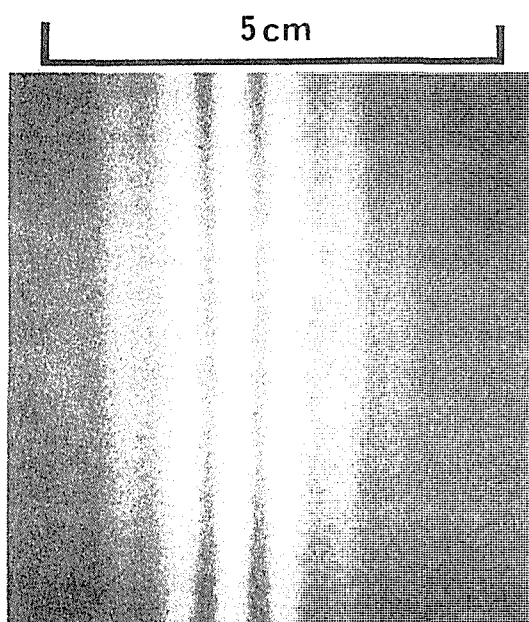
In the other form of the experiment the light from the two slits is allowed to fall on to a screen where the pattern can be seen (Ref 2). In this version the role of interference is more easily understood and so is more satisfactory for use with students than the one described above.

The following experiment is a modification of that found in the Nuffield O-Level Physics course. One of its features is the production of a full sized Polaroid (or 35mm) photograph of the interference pattern for later use (see Figure 2). The experiment can be carried out in an ordinary, darkened laboratory and does not require specialised equipment.

The Experiment

Figure 2 shows the apparatus required for the experiment and how it should be arranged. The components and the steps in the procedure are described below.

1. Twelve volt, 5 amp power supply.
2. Twelve volt (about 40 watt) straight filament car headlamp.
(Alternatively one filament of an appropriate double filament lamp can be used.) The filament is lined up to be parallel to the slits on the slide (see 3). A reasonably large cardboard box (or other suitable cover) with a small opening at the front should be used to prevent unwanted light emerging from the lamp.



POLAROID PHOTOGRAPH
OF INTERFERENCE FRINGES
FIGURE 1

3. Microscope slide covered with carbon from alcoholic Aquadag. The coating should be neither too thick nor too thin. Slits are scribed with a pin and a straight edge so that they are;
 - a) not too thin or else not enough light will get through
 - b) not too thick or you won't see the fringes
 - c) not too far apart or the fringes will be too close together
 - d) as close as possible while still leaving a black strip between them.

A number of pairs of slits are drawn on the one slide and the best one chosen for the experiment. To prevent scratching the carbon coated side is then covered with a second, clear microscope slide taped to the first at each end. Alternatively, a specially prepared photographic negative (homemade or commercially produced) can be used.

4. An opaque screen to eliminate light reflected off the top of the desk below the slits.
5. Screen made from fine-grained tracing paper stuck on a cardboard frame. To be seen most clearly the fringes should be viewed from the back of the screen.

Photographing the Fringes with a Polaroid Camera

6. Supplementary lens with the same focal length as the camera lens. This is taped over the front of the camera. The distance between the supplementary lens and the screen should be equal to the focal length of the supplementary lens (Ref. 3).
7. Polaroid camera focuses on infinity and with the aperture opened as wide as possible (e.g. by using the colour setting) the electric eye is covered up when the picture is taken. The exposure is found by trial and error. For the fringes in Figure 1 the exposure was 60 seconds. If the supplementary lens and the camera lens do not have the same focal length the picture will either be a reduced or an enlarged representation of the fringes.

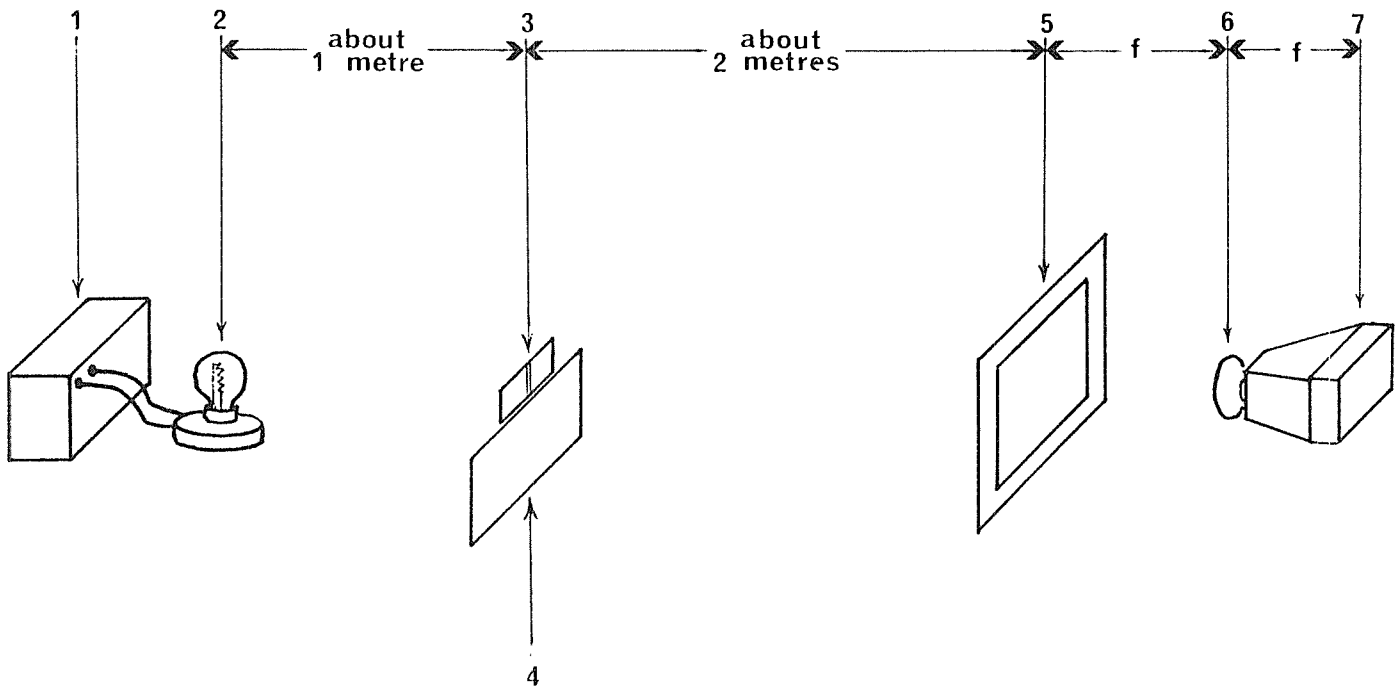


FIGURE 2 THE LAYOUT OF THE EQUIPMENT

Measuring the Wavelength of Light

Measure the distance (D) between the slits and the screen with a metre rule. Measure the average distance (F) between the neighbouring dark fringes of the screen or the photograph.

To measure the distance between the slits remove the slide carrier from a slide projector. Place a transparent ruler with a scale marked in millimetres in the position where the slide would be and focus an image on a white board or projector screen. Measure the average magnified distance between adjacent millimetre marks and calculate the magnification factor of the projector. Without adjusting the projector at all, replace the ruler with the microscope slide backwards or forwards. Measure the average distance between the centres of the magnified images of the two slits and use the magnification factor to calculate the actual distance between the slits (a).

The average wavelength of the light is calculated using the formula $\text{wavelength} = aF/D$. For the fringes shown in Figure 1 $a = 0.22\text{mm}$, $D = 2.010\text{m}$ and $f = 6.33\text{mm}$. Thus

$$\begin{aligned}\text{Average wavelength of white light} &= \frac{af}{D} = \frac{2.2 \times 10^{-4} \times 6.3 \times 10^{-3}}{2.01} \\ &= 6.9 \times 10^{-7}\text{m}\end{aligned}$$

References

1. Gardner, E.D. & White R.T. *Practical Physics*, McGraw-Hill, Sydney, 1972, 67-69.
Lehmann, R.L. & Swartz, C. *Foundations of Physics: Laboratory Experiments*, Holt, Rinehard & Winston, New York, 1969, 133.
2. Nuffield Foundation, *Nuffield Physics: Guide to Experiment 3*, Longmans/Penguin, London, 1967, 160-163.
Tai, A. & Boydell S. *A Guide to Year 11 Practical Physics*, Sorrett, Malvern, 1981, 160-162.
3. Hodgins, R. 'Some Ideas about Close Up Photography', *Australian Science Teachers Journal*, 16 (1), May 1970, 95-100.

VOICE TRANSMISSION ON A LIGHT BEAM (SEN 1984, Vol. 33 No. 1) Ray Ceccato, Wade HS, Griffith

The article by Karl Becker and Benildus Ng in the November issue of SEN, 1983 prompted me to dig out an old circuit which performs a similar task without the need for a laser.

The circuit is based on an article in Transistor Projects Volume 2, a Radio Shack publication, 1974. It consists of a light beam transmitter (a modified transistor radio) and a simple light beam receiver.

For convenience's sake the Tandy Catalogue numbers have been included in the parts list. However, equivalent types should be suitable.

Transmitter Equipment

1 small transistor radio or tape recorder with **transformer output**

1 222 lamp (272-1124)

1 11/2V cell

Disconnect the speaker and connect the following circuit (Figure 1).

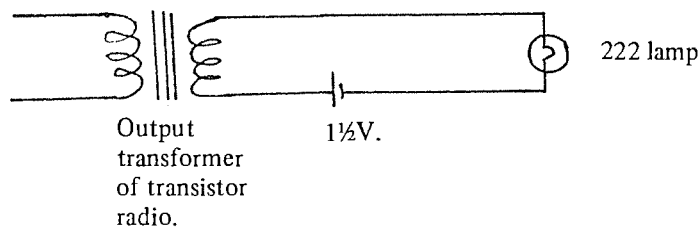


FIGURE 1

The 11/2 V cell provides a base level of illumination. When tuned to a radio station the audio signal modulates the lamp. This causes the lamp to flicker. The modulated light output is detected by a photosensitive receiver circuit (Figure 3) and converted back to an audio signal.

The following modification, (Figure 2), enables the radio to be tuned via the speaker and then switched to the light beam output.

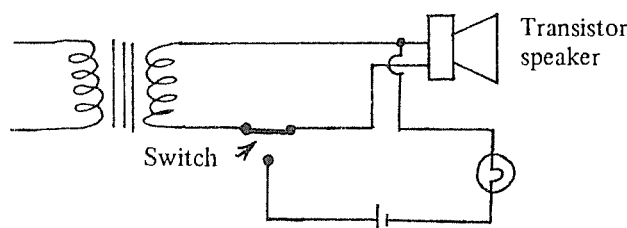


FIGURE 2

Receiver Equipment

1 9V battery

1 capacitor 0.1 μF

1 resistor 10 $\text{K}\Omega$

1 resistor 240 $\text{K}\Omega$

T1 photoresistor FPT - 100 (276-130)

T2 PNP transistor 2N2907 (276-2021)

1 miniature transistor earphone (33-175)

The receiving circuit is simple and straightforward to build (Figure 3).

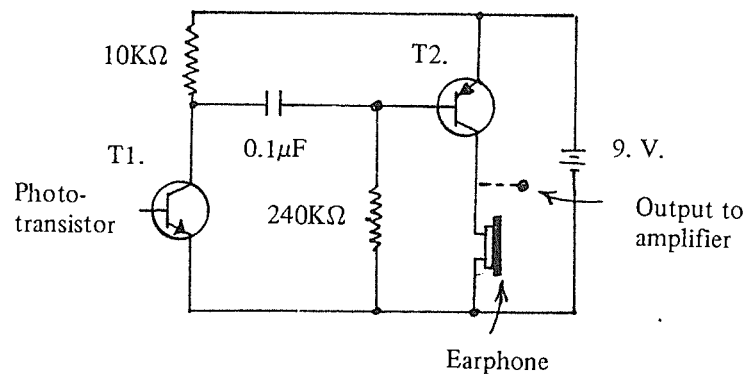


FIGURE 3

The modulated lamp output is allowed to fall on the phototransistor and the audio signal is heard in the earphone. A sheet of paper can be used to interrupt the light beam to show that optical coupling is being achieved (Figure 4).

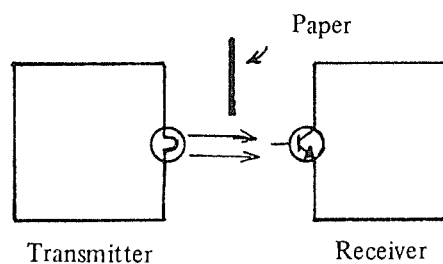


FIGURE 4

The circuit performs well. However, the range is limited to 15-20cm due to the diverging light beam. The optical coupling could be improved by the use of optical fibres as described by Becker and Ng, or by the use of suitable lenses and reflectors.

Output from the receiving unit can be easily amplified for class listening by connecting the SRDU audio amplifier across the earphone or across T2.

Points to Experiment With

1. Vary the base illumination of the lamp by using 3V battery and various combinations of 10Ω resistors
2. Try $2K\Omega$ headphones in place of the earphone
3. Replace the earphone with a $5K\Omega$ - $10K\Omega$ resistor and try a crystal earpiece in parallel

References

- Mims, F.M. *Transistor Projects*. Volume 2, Radio Shack 1974
Mims, F.M. *Optoelectronic Projects*. Volume 1, Radio Shack 1976
Becker, K and Ng, B. Using a Laser and Plastic Fibres to Transmit Speech. SEN 1983, Vol. 32 No. 4.

HYDROELECTRIC GENERATOR (SEN 1984, Vol. 33 No. 4)

N.E. Austen, Leichhardt HS

This generator will drive lights, 6V tape recorder, 6V radio with suppressor, low voltage electric motor. With increasing load current, audible reduction of turbine revolution rate is heard, a useful demonstration for senior physics as well.

Materials

- * 200g coffee can with press-fit lid, 100mm diameter x 120mm high, for turbine
- * 1 extra lid from 200g coffee can for turbine pulley
- * 1 gallon paint can, 180mm diameter x 190mm high, for turbine housing
- * Tin-plate for turbine vanes, escapement and pulley back
- * Brass rod for turbine axle, 4mm diameter x 270mm long
- * 1/2 inch OD copper tube, 40mm long, for water inlet
- * Copper tube for turbine axle bearings

Figure 1. Turbine Vanes

- a. Cut 4 pieces of rectangular tin-plate 40mm x 116mm
- b. Fold 10mm x 116mm flap on each vane for soldering to coffee can

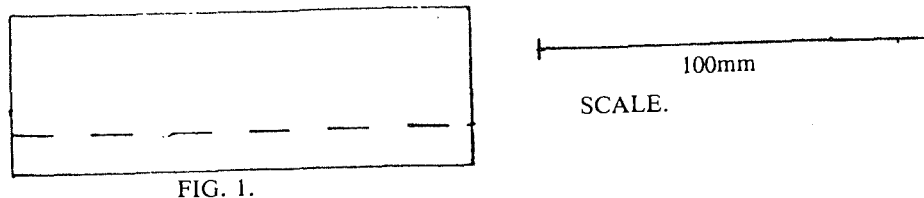


Figure 2. Turbine

- Find and pierce centres in base and lid of coffee can. (Graph paper can be used to find the centre of a circle.)
- Mark position of turbine vanes on coffee can, separated by 90° of arc.
- Solder 10mm x 116mm flap of each vane fully to coffee can at marked positions.
- Enlarge centre holes of lid and base of can outwards to accept the 4mm diameter brass axle rod, 270mm long.
- Insert axle through lid to allow 30mm to protrude outwards.
- Insert axle through can base and firmly close lid.
- Completely solder lid in place.
- Solder axle firmly to can at both ends.
- Slide brass connector onto axle and position about 85mm from end.

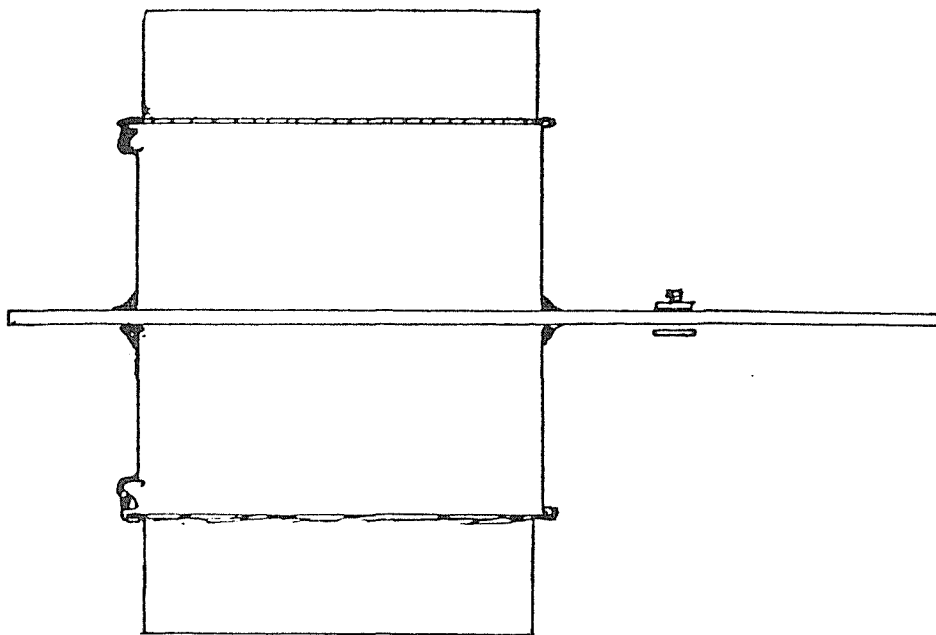


FIG. 2.

Figure 3. Turbine Housing

- a. Find and pierce centres in lid and base of paint can.
- b. Mark 120mm x 70mm escapement on side of paint can as shown.
- c. Cut along solid lines of escapement.
- d. Fold outwards along dotted lines to form two flaps for soldering escapement.
- e. Construct rectangular escapement from a 200mm x 50mm tinplate strip.
- f. Solder escapement to can and prepared flaps. (See Figure 7 for e. and f.)
- g. Enlarge hole in paint can base to accept bearing for turbine axle.
- h. Solder bearing to base of can.
- i. Solder axle bearing to inside of paint can lid. Do NOT enlarge hole in lid as the lid is the axle end stop. The small hole is an oil hole.

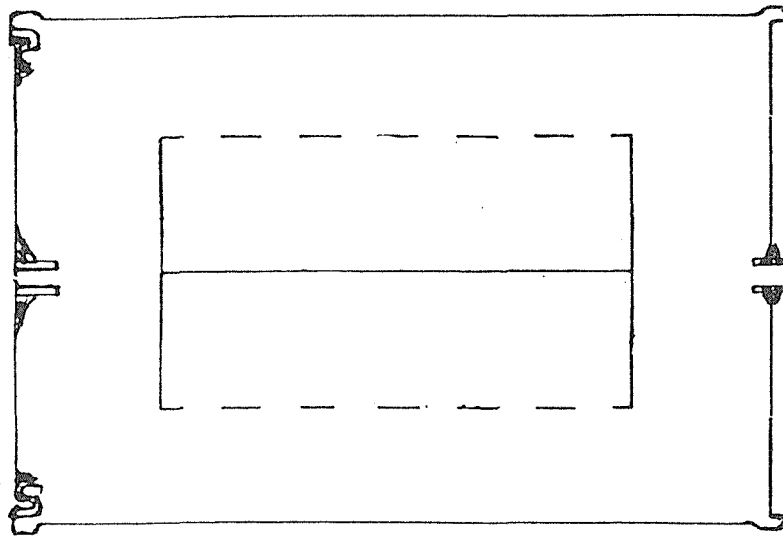


FIG. 3.

Figure 4. Turbine Pulley

- a. Cut 89mm tinplate disc.
- b. Fully solder disc to spare coffee tin lid to form turbine axle pulleys.
- c. Find and pierce lid centre and enlarge hole to accept turbine axle. Do not solder to axle.



FIG. 4.

Figure 5. Water Inlet Tube

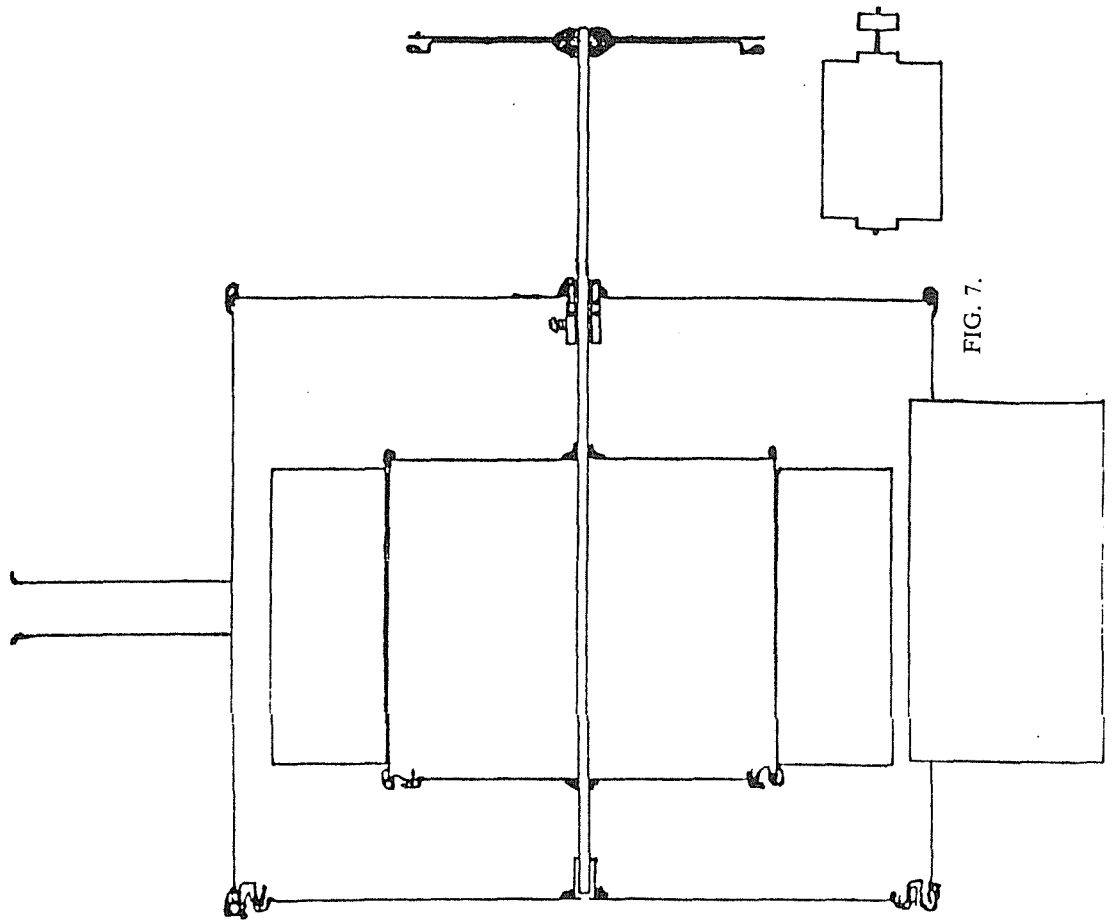
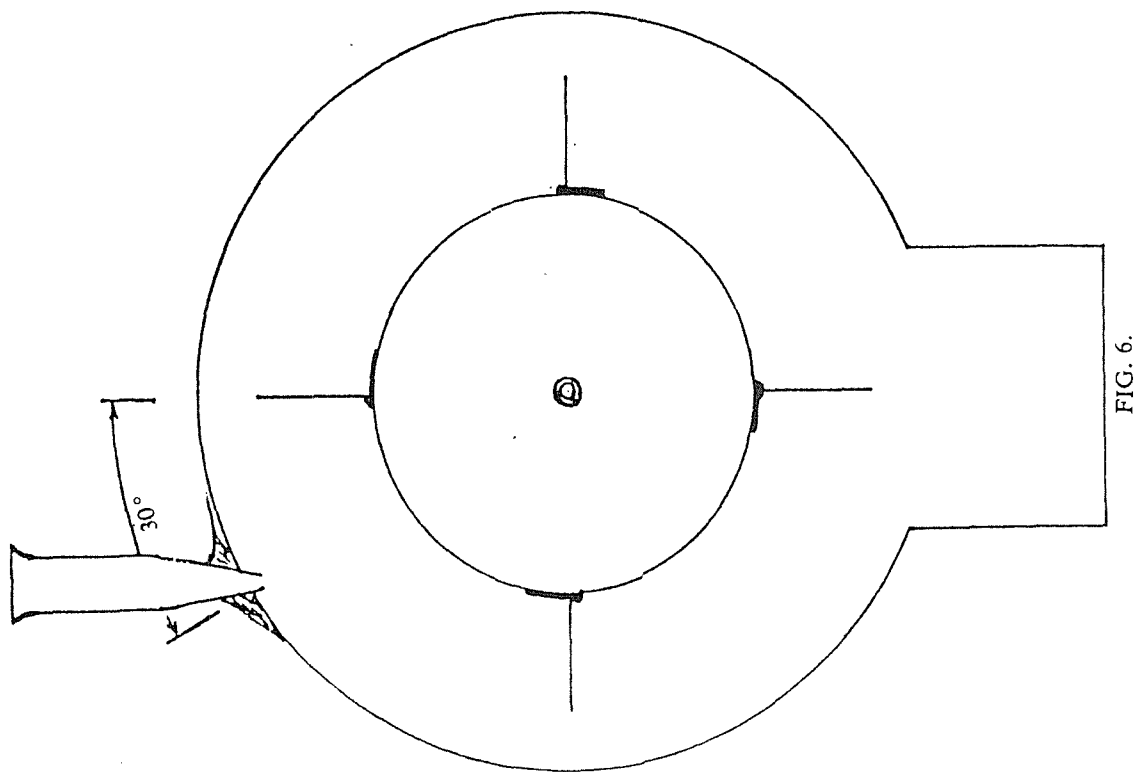
- a. Cut 40mm of 1/2 inch OD copper tube.
- b. Bell end to accept 1/2 inch hose.
- c. Flatten other end to form fan jet.



FIG. 5.

Figures 6 and 7

- a. Pierce paint can from inside to accept fanned end of water inlet.
- b. Solder inlet tube in place.
- c. Check end-play of turbine axle, adjusting axle stop as required.
- d. Solder turbine pulley to turbine axle.
- e. Clamp completed unit to suitable base-board.
- f. Fasten suitable 6V motor to base-board.
- g. Fit motor with suitable pulley to act as retainer for belt.
- h. Fit 3 or 4 suitable rubber bands to turbine pulley and axle of motor.
- i. Attach motor leads to 4mm sockets marked for polarity.



PROJECTILE MOTION (SEN 1984, Vol. 33 No. 4)

George Kelen

Aim

To give meaning to and an alternative description of projectile motion.

Method

1. Get the following equipment.

- * 1 retort stand with bosshead and clamp
- * 1 cardboard protractor (about 450mm diameter)
- * 1 measuring tape
- * 1 garden hose and nozzle
- * sticky tape
- * a metre rule

2. * Fix hose nozzle to give a steady stream

- * Put protractor onto stand by pushing the clamp through the centre of the baseline before attaching the clamp to the bosshead. Tape the top of the protractor to the stand at the 90° mark

- * Put the nozzle into the clamp and set it at 30°

- * Turn on the tap

- * Describe the path of the water

- * Measure the distance from the end of the nozzle to where the water hits the ground

- * Estimate the height of the stream above the ground

- * Turn the tap on slightly more than before and repeat the last two steps

- * Repeat for three more adjustments of the tap

(It is hoped that students can deduce that for fixed angle, the distance travelled is directly proportional to the velocity.)

3. * Put the nozzle at 0°

- * Turn on the tap

- * Measure horizontal and vertical displacements. (Run the hose near a wall.)

- * Increase the angle by 10°

- * Repeat the measurements

- * Keep increasing the angle and the measurements, up to 70°

(It is hoped that the students are able to see that, for a fixed velocity, the horizontal distance is a function of the initial angle (but there is a limit) and the vertical distance is increased with an increase in the initial angle.)

4. Return the nozzle to 45° to see if this gives the maximum horizontal for the same velocity as in part 3

The major problem with this experiment is the tendency of the stream to separate.

RECYCLED CAR PARTS IN THE PHYSICS LABORATORY

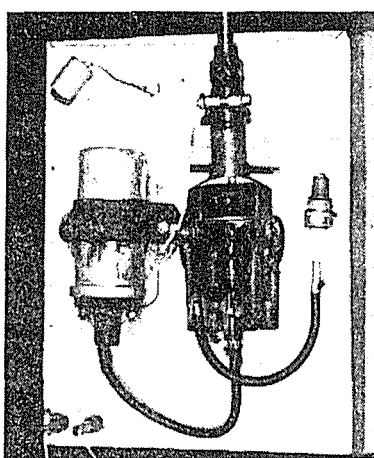
(SEN 1985, Vol. 34 No. 3)

Herbert SImpendorfer, St Paul's College, Walla Walla

In our modern throw away society, cars are junked with many of the component parts in them still in excellent, serviceable condition. These parts are well made and worth a lot of money, yet they are to be found in many official and some unofficial dumping grounds. For the enterprising Physics teacher, dumped cars can be the source of many useful parts for the laboratory. Access to a modest backyard workshop is desirable for some of necessary modifications to components before full use can be made of them. In this article I will show how I have used various car parts in the HSC course and also for other applications.

Elective 4AE - Automobile Electrical Systems

Obviously car parts can be used in this elective. Also enough parts can be retrieved from wrecked cars to make it possible for all students to have hands on experience with nearly all aspects of this course. Parts which can be removed from wrecked cars include all the lights, ignition coil, distributor, high tension leads, spark plugs, relays, horn, turn indicator unit, fuses, switches, current regulator, voltage regulator, starter motor and generator (or alternator if it is a late model car).



An ignition system. With 12V D.C. connected as shown, a spark will appear at the spark plug once per revolution of the handle. The condenser can easily be disconnected to observe the effect this produces. The sparks inside the distributor cap are readily observed in this model, but never seen in a vehicle.

The lights should be taken out of their sockets, washed and prepared for use by soldering short bare copper wires to the terminals. Students can then connect them to a power pack using alligator clip connecting leads for a variety of circuits. An important point here is that the car battery is not used for any of the circuits described in this article. Batteries are heavy, dirty and messy. They also can wreck clothes with acid holes. It is much more convenient to use the normal school power pack on 12V DC.

The distributor requires a little modification before use. It needs a small piece of bent rod welded onto the end of the shaft to make a handle. Turning this will then cause the rotor button and cam to turn. Students can then use this distributor and other salvaged components to build a working ignition system. They will need a piece of thick chipboard, some nails to anchor the components, some connecting wire, soldering equipment and a power pack. There is some risk of an electric shock if the wrong parts are touched when the system is operational, but there is no danger for a person enjoying normal health. It is desirable to cut away part of the distributor cap to expose the moving parts inside. Incidentally, this setup will provide enough high tension to operate cathode ray tubes, like the Maltese Cross apparatus, but the result is not as good as from an induction coil.

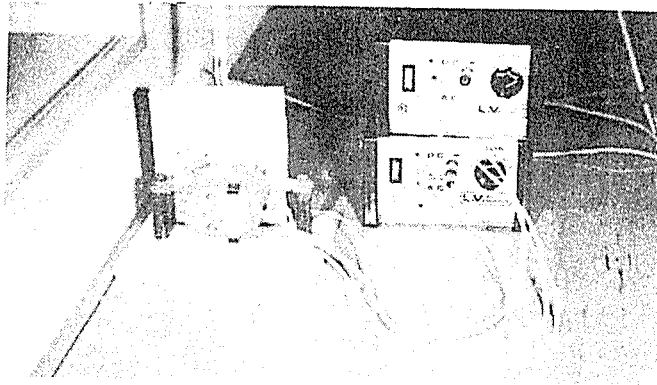
Using other components from cars, students can also construct:

- * a relay circuit operating the headlights or horn
- * a full headlight, parking light, tail light and number plate light circuit
- * a blinker circuit
- * a courtesy light circuit
- * a starter motor circuit
- * a current and voltage regulation system.

Even though a battery is not used to supply power, it is desirable to have a cut-away battery on display. I used a plastic cased battery, spent about half an hour cleaning it on the outside and flushing the acid and residues from the inside, then using a hacksaw to cut away pieces of the case, exposing the plates and connectors. It is also useful to have a cut away ignition coil for display. Care is needed when doing this, as the secondary wires are so thin it is easy to miss them.

Elective 3 - Rotation

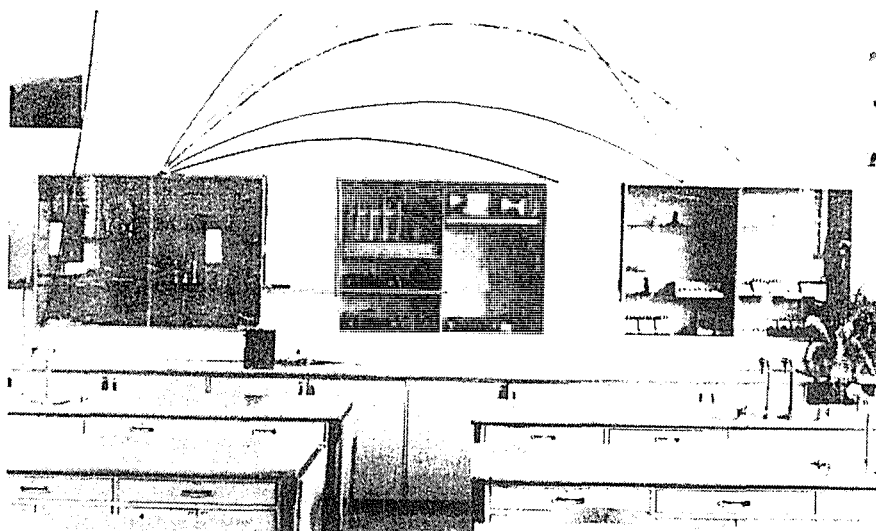
The windscreen wiper motor is a very useful item from a car. Normally it works from 12V DC, but if connected to lower voltages, the motor turns more slowly and will suffer no ill effects. Thus the motor can be used as a variable speed device.



A rotary switch made out of an old windscreen wiper motor. Rainbow cable is used to connect the terminals of the rotary switch to the display.

First, some of the peripheral pieces to the motor have to be removed, leaving a rotating shaft. An arm of any desired length is then welded at right angles to the shaft. Some basic Rotation experiments can be done with this apparatus. A flat circular table can also be connected, either directly or via a pulley and belt, for other experiments.

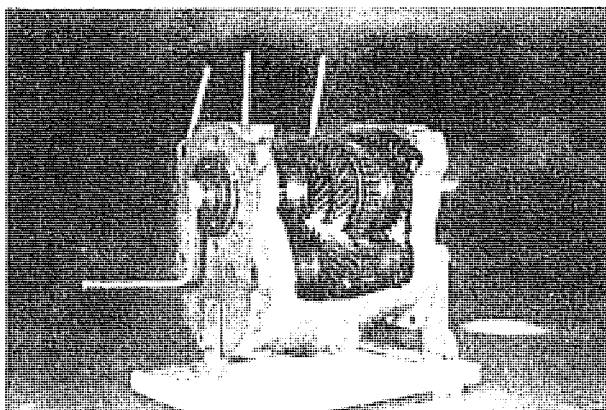
Rotational momentum experiments make use of a Prandtl stool, which can also be made from junked car parts. The base is a steering wheel, upside down. Part of the shaft is left with the wheel and a suitable large ball bearing race is welded to the shaft at a convenient height. Some strengthening braces may need to be added. A circular wooden or metal disc attached to the outside of the race completes the stool. If you have access to an early model Ford Zephyr or car using a similar front suspension system, pull apart this unit and the shaft and bearing are ready to use.



The Projectile Motion Display on the back wall of the Physics Laboratory. The lights come on in a sequence to simulate the flight on a projectile with an initial velocity at an angle of elevation of 45° .

Core Units

The variable speed motor described above can also be incorporated into a rotary switch. A small arm is welded at right angles to the shaft and a 'brush' is attached to the end of the arm. This brush can be any springy conductor metal. This brush makes contact with the top of the nailheads which have been nailed into particle board of thickness less than the length of the nails. The sharp ends of the nails are connected to lights in a display, in which lights go on and off in some sequence. I have used this set up for a simulated projectile motion display across the back wall of the Physics lab and for a simulated SHM display across the top of the blackboard. I have used instrument panel lights from wrecked cars and if it is necessary, of course, used lights of the same wattage for an even effect. If two power packs are used, both the speed of the display and the brightness of the lights can be varied, as the brightness of lights depends on the applied voltage.



A gear box ready for use. Students stand behind the unit, turn the handle with the right hand, and operate the gear levers with the left hand. The effect of the gear changes can be seen by observing the output shaft.

Other Ideas

I have also used retrieved manual gearboxes. The modifications are rather extensive. Shafts need to be cut off close to the casing, bell housing and extension housing removed and mainshaft and input shaft cut off close to the remaining housing. Parts of the casing need to be cut away, so that the action of the cogs can be seen. Also, small handles should be welded onto the remnants of the shafts and onto the gear change shafts, so that gears can be changed while the handle on the input shaft is turned. Some strategically painted sections and mounting onto a solid base completes the job. Students in lower classes love to 'play' with these modified gearboxes and are hopefully learning about gear ratios and mechanical advantage.

The gearbox of a car is surprisingly small, but quite heavy. Motorcycle gearboxes operate differently to those on cars, and it is worth getting hold of one for similar modifications.

I have also modified a differential in the same way, removing all external parts except the differential carrier, and cutting the half shafts just clear of the differential bearings. Handles are welded on to the pinion as well as the half shafts. It is fun to use, but I do not know where it would fit into a Science course.

It may also seem logical to retrieve a whole engine, but I have found it adequate to use lawnmower engines to demonstrate the principles of two and four stroke systems. After dismantling, carefully planned cuts are made with a hacksaw to expose the moving parts. Again, a bit of paint, a solid handle to turn the crankshaft and a solid base are necessary. It is possible to have the spark plug working on these models. To have these engines 'operating' in a display situation requires the connection of a small, low speed motor. I have used a windscreen wiper motor coupled to the crankshaft. The inbuilt reduction gears produce a low enough speed and adequate torque.

The carburettor on a lawnmower is much simpler than the same item on a car and also much easier to use in a demonstration. They are easy to cut away as the metal is an aluminium alloy.

It is also a simple matter to make a working speedometer with a handle turning a small remnant of the speedo cable. A direct connection is not satisfactory, as the speed required is too high for hand turning. Some way of obtaining a turn ratio of about 1:5 is necessary. Cutting away part of the speedo housings shows how it works.

Ball bearings from various ball bearing races can, of course, be used in many experiments. I have found that the larger ball bearings are the most useful.

These are just some of the ways in which car parts can be used. Once you get a few parts you will, no doubt, find many other applications. At our school, we find the most useful parts of all are small light globes. We use them in Junior Science classes for practical work in electrical circuits and conductivity testing, as well as in senior classes, as described above.

Getting Started

The idea of going to a dirty old wrecked car and pulling off bits and pieces may be rather daunting for some teachers. To be honest, the first part of the process is dirty, but one can tackle the job philosophically. That is the price we pay for getting parts that are well made, will last for years, serve our purposes admirably and cost nothing. When the parts are first removed, as much gunk as possible is removed by scraping with a putty knife or similar tool. Then an old dish with a few cm of petrol in it is used. The salvaged article is put in the dish and an old paint brush used to help brush off the rest of the grime. The final clean is done in a rather strong and hot detergent solution. I use Rinso powder. Some parts will need to be re-oiled if they contain moving parts. If cleaned in this way, students will not need to wash hands after handling the parts.

Of course, if you have a friend who is happy to take the parts off the cars, or who has steam cleaning equipment, so much the better, because these two jobs are the dirtiest in the whole process.

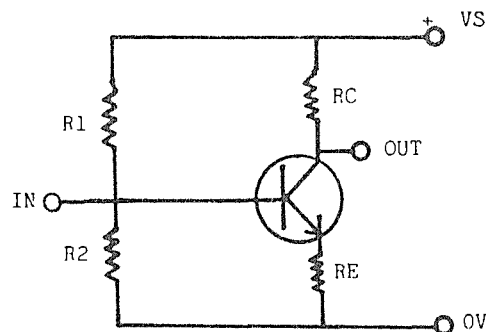
Essential tools would be found in a good backyard workshop. A good set of SAE spanners, including sockets, will take apart most British, Australian and US built vehicles and metric sizes are required for European cars. Access to an arc welder is necessary and a good angle grinder saves a lot of hard work, especially when cutting through hardened steel. A heavy all-metal vice on a bench is a must.

THE VOLTAGE DIVIDER COMMON EMITTER TRANSISTOR AMPLIFIER (SEN 1985, Vol. 34 No. 3)

Chris Wiecek, Warilla HS

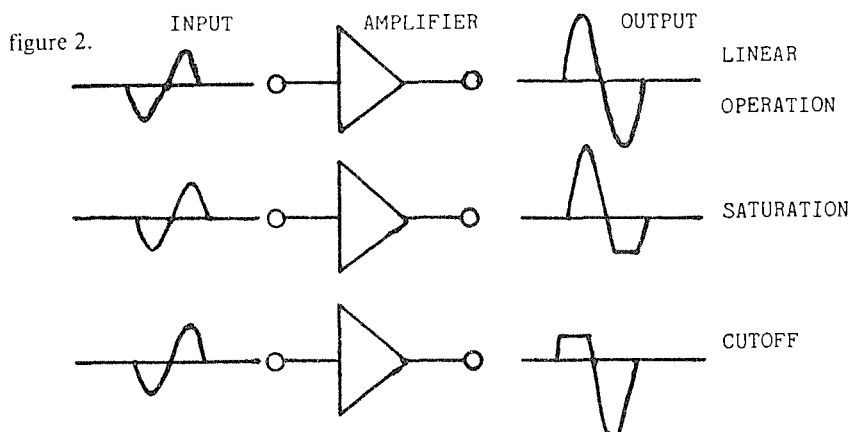
The use and operation of common emitter circuits is part of the HSC Physics elective, Electronics and the 4 Unit Science elective, Electronics. The most stable and practical of these circuits is with voltage divider bias. (See Figure 1.)

figure 1.



A transistor must be DC biased in order to operate as an amplifier. A DC operating point must be set so that signal variations at the input are reproduced at the output. Biasing is determined by the resistors R_1 , R_2 , R_C and R_E . These define a certain current and voltage condition for the amplifier called the DC operating point or the Q point (quiescent point). Improper biasing will cause distortion in the output signal. This distortion could be saturation or cutoff or both.

Saturation is when an increase in base current does not lead to a corresponding increase in collector current, because the collector current is limited by R_C and R_E , ie. I_C cannot exceed $V_S / (R_C + R_E)$. Cutoff occurs when the base voltage is too low to forward bias the base emitter pn junction and therefore no current can flow. (See Figure 2.)



The design of an amplifier circuit is not simple, however values for the resistors R_1 , R_2 , R_C and R_E can be found easily with the use of the following computer program. The program is written for the Apple computer available in many schools. The program requires the input of values of R_1 , R_2 , R_C and R_E with the supply voltage V_S and the gain of the transistor $B_{dc}(h_{FE})$. The program then computes V_B , I_C , V_E , V_{CE} , etc. and indicates if the transistor is saturated or cutoff. The effect of varying these values can thus be rapidly checked by computer and hence students can design their own amplifying circuit.

B_{dc} values are available in a variety of sources such as the data section of Dick Smith's catalogues, eg. B_{dc} for BC548 transistor is quoted at 110-800 in the catalogue and the lower value should be taken. However, a narrower range of B_{dc} can usually be found in manufacturers' data sheets,

eg. B_{dc} for a BC548A with $I_C = 2\text{mA}$ is 110-220 (average value = 180)

B_{dc} for a BC548B with $I_C = 2\text{mA}$ is 200-450 ($A_v = 290$)

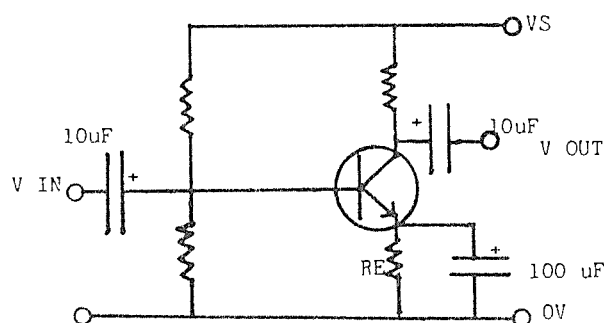
B_{dc} for BC548C with $I_C = 2\text{mA}$ is 420-800 ($A_v = 500$)

Students should be aware that the operating point should allow equal voltage swings above and below the Q point without distortion, ie. $V_{CE} + V_E = V$ output should be about half the supply voltage.

The final constraint is on I_C . It must be less than the maximum rating allowed for a given transistor, eg. for a BC548 it is 100mA.

Finally have your students construct and test the amplifier with a signal generator and a CRO. Add capacitors at the input and output (Figure 3) and use the CRO to measure the input and output voltages. Compare $V_{\text{output}}/V_{\text{input}}$ to R_C/R_E . Finally connect a capacitor in parallel with R_E and note the effect on the voltage gain.

figure 3.



Special thanks to Peter Carnaby, Year 9 student, Wally Erven and Jim Webb, staff, for help with the program.

List

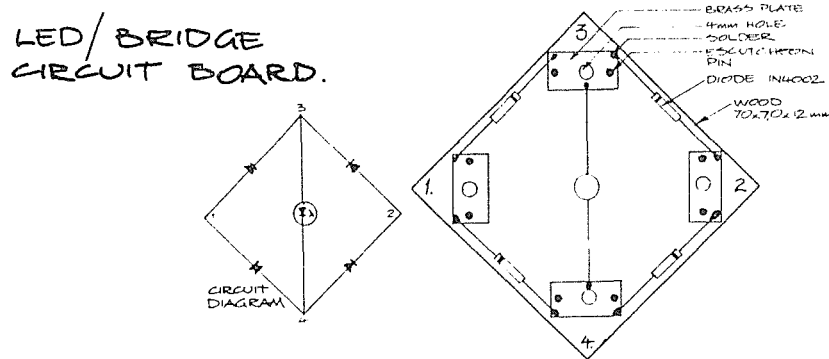
```
10  Home
20  Print "This program computes VB, VE, VCE, IB, IC, IE"
30  Print "For the circuit given RI, R2"
40  Print "RC, RE, VS and DC BETA"
50  Print : Print : Print
60  Print "Press a key to continue": Get Z$
70  Home
80  Input "R1 in Ohms"; R1
90  Input "R2 in Ohms"; R2
100 Input "RC in Ohms"; RC
110 Input "RE in Ohms"; RE
120 Input "VS in Volts"; VS
130 Input "DC Beta"; B
140 Home
150 RIN = B*RE
160 If RIN = 10*R2 Then R = R2
165 If R = R2 Then Go to 170
167 R = R2*RIN / (R2 + RIN)
170 VB = (R / (R + R1))*VS
180 VE =VB - .7
190 IE = VE / RE
200 IC = IE
210 VCE = VS - IC*(RC+ RE)
212 RB = (RI*R2) / (RI + R2)
214 IB = (VB - .7) / (RB +(B + I)*RE)
220 If VE 0 Then print "Transistor is cutoff"
230 If VE 0 Then Go to 350
240 If VCE 0 Then print "Transistor is saturated"
260 Print "VB ="; VB; "V"
265 Print "IB ="; IB; "A"
270 Print "VE ="; V; "V"
280 Print "VCE ="; VCE; "V"
290 Print "IC ="; IC; "A"
300 Print "IE =";IE; "A"
350 Input "Do you want to finish. . ."; R$:If R$ = "Y" Then 2000
352 Print "Do you want to restart": Get A$: If A$ = "Y" Then 10
355 Print "Press a key for another": Get Z$
410 Gosub 1000
420 Goto 140
1000 REM variable changes
1010 Print "R1 in Ohms"; R1;; Input Q1$: If Q1$ = " " Then R1 = Val(Q1$)
```

```
1020 Print "R2 in Ohms"; R2;; Input Q2$: If Q2$ " "Then R2 = Val(Q2$)
1030 Print "RC in Ohms"; RC;; Input Q3$: If Q3$ " "Then RC = Val(Q3$)
1040 Print "RE in Ohms"; RE;; Input Q4$;: If Q4$ " "Then RE = Val(Q4$)
1050 Print "VS in Volts"; VS;; Input Q5$: If Q5$ " "Then VS = Val(Q5$)
1060 Print "DC Beta"; B; Input Q6$: If Q6$ " "Then B = Val(Q6$)
1070 Return
2000 End
```

EXPERIMENTS WITH MULTITAP COILS (SEN 1986, Vol. 35 No. 3)

N.E. Austen, Leichhardt HS

The following experiments use Austen coils, which are hand wound coils with a minimum or two tapplings for a number of windings, ranging from 100 to 4000 turns, most having 200 and 2500 turns.



Experiment 1.1

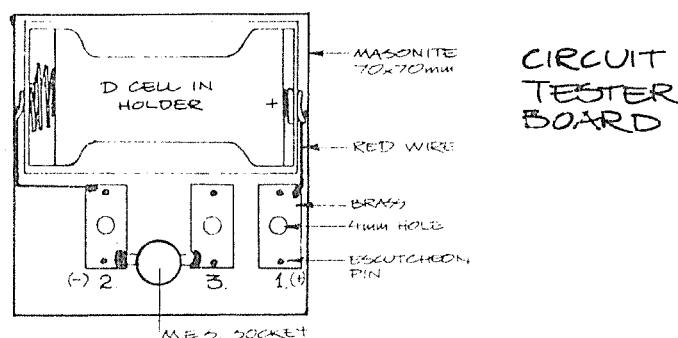
- Place the coil flat on the bench with labels up. Join the 0 and 2 000 turn terminals to the LED/Bridge Circuit Board terminals 1 and 2 respectively. Balance a bar magnet, standing on its North pole, vertically in the coil-former centre. Snatch the magnet from the coil as rapidly as possible. Describe what happens.
- Reverse the magnet so that the South pole is snatched from the coil. Describe what happens.
- Invert the coil, label side now being down. Snatch first North and then South poles from the coil. Describe what happens.
- Turn the coil over again. Reverse the wires at the coil terminals. Continue as in c. above. Record the results.
- Hold the coil, still connected to the LED/Bridge circuit, in the left hand in such a fashion that the North pole of the bar magnet can be moved in and out of the coil former centre as rapidly as humanly possible. Record observations.
- Repeat as in e, substituting the South pole for the North. Record observations.

Experiment 1.2

Join the 0 and 2 000 turn terminals to the 3 and 4 LED/Bridge terminals respectively. Repeat the experiments 1.1 a to f, recording all observations.

Experiment 2.1

Design a suitable test circuit for the galvanometer. In NSW public schools this is a centre zero, 60 - 0 - 60. The right terminal is normally red, the left black. My circuit tester is shown below. It is used as a conductivity tester and circuit continuity tester with the cell in place and as a voltaic cell with the cell removed, the 2.2v globe being changed to 1.2v and zinc and copper electrodes fitted with 4mm plugs being inserted from below into holes 2 and 3 respectively.



A lead with 4mm plugs is specially prepared by soldering a $K\Omega 1.4$ watt resistor onto the wire at one end before one of the plugs is fitted.



Experiment 2.1

- Connect hole 1 of the Circuit Tester Board to the right hand terminal of the galvanometer using the Protective lead. Connect hole 2 to the left galvanometer terminal. Record results.
- Reverse the wires at the galvanometer terminals. Record results.
- Complete the following statements:
 - when the right galvanometer terminal (red,+) is positive and the left terminal (black, -) is negative, the needle leaves centre zero, moving to the
 - when the left galvanometer terminal is positive

- iii. when conventional current flows into the right galvanometer terminal, the needle moves to the
- iv. when conventional flows into the left galvanometer
- v. if the galvanometer needle deflects to the left, the right
- vi. if the galvanometer needle swings right, conventional current is flowing into the galvanometer terminal and out of the coil terminal.

Experiment 2.2

Place the coil flat on the bench so that the labels face up. Connect 0 terminal to the left galvanometer terminal and the 250 turn terminal to the right galvanometer terminal. Record observations for experiments 2.2 to 2.4.

- a. Slowly introduce the North pole of a bar magnet into the coil former centre.
- b. Balance the North pole stationary in the coil.
- c. Slowly remove the North pole.
- d, e, f. are as a, b, c, in 2.2 above, but the South pole is used.
- g, h. Increase the speed of movement of the North pole as in a. and c. above.
- i, j. Repeat as in g, h, above, but using the South pole.

Experiment 2.3

Change the lead from the 250 to the 500 turn coil terminal. Move the North pole at a moderate speed into and then out of the coil former centre for each change of coil terminal. Attempt to maintain the same moderate speed for all motion.

Experiment 2.4

Hold 2 then 3 magnets firmly together, using heavy rubber bands, with LIKE poles in contact. Repeat Experiment 2.2.

Experiment 2.5

- a. Summarise the parameters which affect the development of electric current induced in the coil.
- b. Tabulate your results for 2.2 a, c, d, f, g, h, i, j, using the following table.

	Coil Terminal Polarity		Induced Current direction Within Coil	Magnetic Polarity ABOVE Coil by induced Current	Magnetic Pole used and Motion Direction
	Zero	Other			
2a					
c					
d					
etc.					

Coil Terminal Polarity: record as + or - from galvanometer deflection and coil connection to galvanometer terminal. Induced Current Direction: record as within coil.



Note: Induced current direction WITHIN coil is TOWARDS the POSITIVE COIL TERMINAL which makes THAT TERMINAL LIVE and the CONVENTIONAL CURRENT EXTERNAL to the coil is then flowing from + to - coil terminal!

Magnetic Polarity above coil: use Right Hand Rule of Thumb.

Magnetic Pole used: use N towards - for North pole into coil centre.

Motion Direction: use N away; S towards; S away.

From the above table, formulate a rule to predict the direction of the current induced by the motion of the magnetic pole used.

Experiment 3.1

Connect the zero coil terminal to cathode ray oscilloscope earth and the 250 coil terminal to the CRO input. Lay the coil label side up on the bench. Predict the polarity of the coil terminals and the direction of the current within the coil and in the CRO when:

- a north pole approaches
- recedes from the coil centre
- a south pole approaches
- recedes from the coil centre

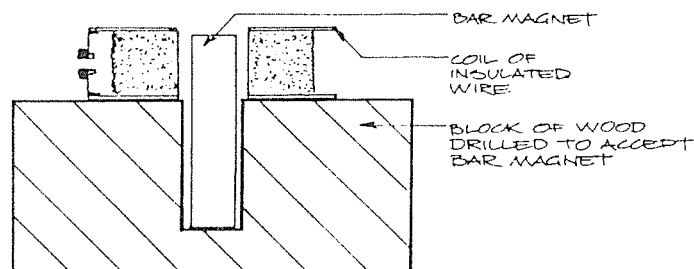
Observe what happens as

- e. the speed of motion of the pole is increased
- f. the number of turns in the coil is increased
- g. the number of like poles is increased
- h. the magnetic pole is moved in and out of the coil centre as evenly and rapidly as possible

Experiment 3.2

- a. Balance the magnet vertically on the bench and move the coil up and down about the magnet.
- b. Attempt to spin the coil about a line perpendicular to the magnets.
- c. Examine the standard, hand operated demonstration model dynamo. Compare and contrast the working of this model with the working of the previous coil magnet experiments. Explain the reason for the improved performance of the model.
- d. Connect the dynamo terminals to a suitably adjusted CRO.

Experiment 4.1



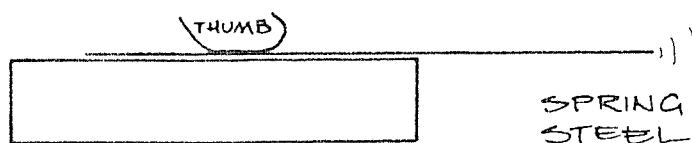
Connect the 0 and 2 000 turn terminals, preferably using a shielded cable, to an amplifier speaker system. (A tape recorder on Pause/Play/Record with an external microphone input would do.)

- a. Tap the coil or support moderately firmly with the fingertip or fingernail. What does the resulting sound remind you of?
- b. Examine a dynamic microphone insert. Describe and name the working parts. Discuss the operation. How does the insert differ from that used in part a above?
- c. Connect the microphone directly to the CRO. Adjust the volts/cm to maximum sensitivity and time/cm to a suitable moderately slow speed. Whistle into the microphone. Comment on the CRO trace.

Experiment 5.1

Use the same support as in 4.1. Connect the 0 and 2 000 turn terminals to a galvanometer. Sweep a soft iron rod or ferrite rod horizontally across the upper surface of the coil former fairly slowly from side to side, crossing the centrally located magnet. Record the meter response as the soft iron:

- a. approaches
- b. recedes from the centrally located magnet
- c. increase the sweep speed of the soft iron as desired
- d. explain the metre response
(Hint: try mapping the magnet's field, using iron filings on cardboard sheet, as the soft iron moves towards, then away from the central magnet.)
- e. Connect the coil to the amplifier system as in 1.4. Hold, as near to the coil core magnet as possible, vibrating magnetic materials such as:
 - i. an electric guitar string stretched between bridges on a suitable piece of fairly dense timber. (A tensioning device could be added)
 - ii. tuning forks of all available frequencies
 - iii. a piece of spring steel pressed firmly by the left thumb against a short length of suitably dense timber. (Movement of the thumb can alter the length of protruding spring steel. pluck the free end with the right forefinger.)



- iv. spanners, suspended by light nylon fishing line. (Strike with a suitable light hammer such as a nail head.)
- v. a pinch bar, suitably suspended. (Try for harmonics.)
- vi. a high quality steel crow bar, suitably suspended. (Try for harmonics.)
- vii. any other suitable material such as tubes, plates, etc.
- f. Be inventive! Experiment wildly! Write the First Movement of the Inductive Symphony!
- g. Examine an electric guitar pick-up. Sketch and name the working parts.
- h. Compare and contrast the working of the microphone and the pick-up.